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EPA Superfund
Record of Decision:

CENTRAL CITY, CLEAR CREEK
EPA ID: COD980717557
OU 04
IDAHO SPRINGS, CO
09/29/2004

Central City/Clear Creek Superfund Site
Operable Unit 4

Record of Decision

DECLARATION OF THE RECORD OF DECISION

SITE NAME AND LOCATION

The Central City/Clear Creek Superfund Site is located 30 miles west of Denver, Colorado. The Study Area for the Site encompasses the Clear Creek watershed, which spans approximately 400 square miles. The Study Area is divided into four Operable Units (OUs). OU1 initially called for passive treatment with constructed wetlands as the proposed remediation of acid mine discharges from five tunnels within the Study Area that were identified as impacting the stream system with heavy metals: Big Five Tunnel, National Tunnel, Argo Tunnel, Gregory Incline, and the Quartz Hill Tunnel. Full scale application of passive treatment has not been implemented at any of the five tunnels. OU1 has since been modified by OUS and the Argo tunnel discharge is treated with conventional active treatment. OU2 addresses remediation of mine tailings and waste rock in the immediate proximity of the five discharging tunnels referenced under OU1. OUS called for addressing the Burleigh Tunnel discharge with passive treatment, the Argo Tunnel discharge with active treatment, assessment and collection of ground water in the Idaho Spring area (Virginia Canyon) as well as remediation of a number of additional waste piles within the Clear Creek basin. This ROD addresses OU4, the North Fork basin which includes the North Fork of Clear Creek and its tributaries and the Quartz Hill, Gregory Incline and National Tunnel mine discharges which were first identified in OU1. The Central City/Clear Creek area was one of the most heavily mined areas in Colorado during the late 1800's, producing large quantities of metals such as gold, silver, copper, lead, nickel, and zinc.

The U.S. Environmental Protection Agency (EPA) Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) Site Identification Number is COD980717557.

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedy for the Central City/Clear Creek Superfund Site, OU4. This ROD has been developed in accordance with the requirements of the Comprehensive, Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, 42 U.S. Code (USC) 9601 et. eq. as amended, and to the extent practicable, the National Oil and Hazardous Substance Pollution Contingency Plan (NCP), 40 CFR Part 300. This decision is based on the Administrative Record for the Central City/Clear Creek Superfund Site.

The remedy was developed by Colorado Department of Public Health and Environment (CDPHE) and EPA. CDPHE and EPA jointly proposed the remedy to the public in the proposed plan and now jointly approve the selected remedy.

ASSESSMENT OF THE SITE

The response action selected in the ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment. Such release, or threat of release, may present an imminent and substantial endangerment to public health or welfare or the environment.

The remains of historical mining operations in the North Fork basin include numerous mine waste piles which erode and leach into the North Fork of Clear Creek, as well as mine tunnels that drain acidic water containing high metal concentrations to the North Fork of Clear Creek. The high concentrations of metals in the North Fork prevent the survival offish downstream of Black Hawk. In addition, the North Fork of Clear Creek's subsequent contribution to the main stem of Clear Creek adversely impacts the main stem of Clear Creek by contributing significant metal loading. While the main stem of Clear Creek does support aquatic life including fish, the diversity and abundance of aquatic life in the main stem of Clear Creek are limited by the metal loading from the North Fork of Clear Creek.

DESCRIPTION OF THE SELECTED REMEDY

The selected remedy for OU4 addresses contaminated surface water, ground water, and sediment from mine waste piles within the Study Area. The cleanup strategies will address threats through the capping or removal of waste piles and treatment of point and non-point sources of surface water contamination.

The major components of the remedy include:

<u>The water collection, conveyance, and treatment components</u>:

1. An interceptor trench at the base of the Gregory Gulch alluvium near the upstream entrance of the Gregory Gulch box culvert.
2. A sump and pump station on the up gradient side of the Gregory Gulch interceptor trench, and a pipeline connecting to the Bates Hunter Mine Water Treatment Plant.
3. A pump station and pipeline connecting the Gregory Incline discharge to the Bates Hunter Mine Water Treatment Plant.
4. A gravity pipeline configured as full-pipe flow conveying the National Tunnel discharge downstream to the passive treatment system location.
5. A passive treatment system that consists of Sulfate Reducing Bioreactor (SRBR) cells. The effluent from the SRBR cells would flow to a Free Water System (FWS) cell for polishing prior to discharge to the North Fork of Clear Creek.

<u>Sediment reduction components</u>:

1. Removal of the following mine waste piles: Niagara, Centennial, Old Jordan (to Druid), and Gregory Gulch No. 3. Waste materials would be trucked to an on-site mine waste repository or a centralized mine waste pile for capping and disposal, or would be disposed of at a landfill off-site.
2. Excavation, capping, or stabilization of the following mine waste piles and adjacent areas: Argo, Pittsburgh, Mattie May, Baltimore, Iroquois, Anchor, Hazeltine, Druid, and Upper Nevada Gulch piles. (Soil Cap and Revegetate on the south side of Nevada Gulch and cap with rock on the north side).
3. Stabilization of stream channels adjacent to capped waste piles.
4. Construction of run-on ditches upslope of the Mattie May, Baltimore, Hazeltine, Pittsburgh, Upper Nevada Gulch Piles, Iroquois, Anchor, Druid, and Argo.

Construction of sediment dams in Russell Gulch above the confluence with Willis Gulch, in Willis Gulch above the confluence with Russell Gulch, in Russell Gulch below the confluence with Lake Gulch, and in

Nevada Gulch below Nevadaville. The treatment of the Gregory Gulch ground water, Gregory Incline discharge, and National Tunnel discharge, is considered restoration of surface and/or ground water under CERCLA Section 104(c) and NCP Section 300.435(f). Consequently, these and other restoration activities are considered remedial action for up to ten years.

Institutional controls will be established in areas in which waste will remain in place once the remedy has been fully implemented. These institutional controls will limit human exposure to mine wastes and ensure that the integrity of components of the remedy is maintained. The remedy will also include high- and low-flow sampling of the North Fork of Clear Creek and main stem Clear Creek (upstream and downstream of the North Fork of Clear Creek).

STATUTORY DETERMINATIONS

The selected remedy for OU4 is protective of human health and the environment, complies with federal and state requirements that are applicable or relevant and appropriate for the remedial action, is cost effective, and utilizes permanent solutions and alternative treatment technologies to the extent practicable.

Because the remedy will result in hazardous substances or pollutants or contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within 5 years after initiation of the remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

ROD DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section of this ROD. Additional information can be found in the Administrative Record for this Site.

- COCs (Contaminants of Concern) and their respective concentrations. (Section 7.1.1 and 7.2.1)
- Baseline risk represented by the COCs. (Section 7)
- Remediation Goals established for COCs and the basis for the levels. (Section 8.2)
- Whether source materials constituting principal threats are found at the Site. (Section 11)
- Current and future land and water use assumptions used in the baseline risk assessment and ROD (Section 6)
- Potential land and ground water use that will be available at the Site as a result of the selected remedy. (Section 12.5)
- Estimated capital, operation and maintenance (O&M), and total present worth costs; discount rate; and the number of years over which the remedy cost estimates are projected (Section 12.2.5)

AUTHORIZING SIGNATURES

This Record of Decision documents the selected remedial action to address the contamination at the Central City/Clear Creek NPL site, Operable Unit 4.

The following authorized official at the Colorado Department of Public Health and Environment approves the selected remedy as described in this ROD.

Howard Roitman 9-29-04

Howard Roitman
Director of Environmental Programs
Colorado Department of Public Health and the Environment

Date

The following authorized official at EPA Region 8 approves of the selected remedy for the Central City/Clear Creek NPL site, Operable Unit #4 as described in this ROD.

Max H. Dodson

9/29/04

Max H. Dodson
Assistant Regional Administrator
Office of Ecosystems Protection and Remediation
U.S. Environmental Protection Agency, Region 8

Date

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Central City/Clear Creek Superfund Site
Operable Unit 4

Decision Summary

SECTION 1

SITE NAME, LOCATION, AND DESCRIPTION

The Clear Creek/Central City Superfund Site Study Area (CERCLIS ID #COD980717557) is located in Clear Creek, Gilpin, and Jefferson Counties, Colorado, and is situated within the 400 square mile Clear Creek watershed. The Clear Creek/Central City area was one of the most extensively mined areas in Colorado. However, there are considerable portions of this area that have not been impacted by historical mining operations. Therefore, the entire Clear Creek watershed is referred to as the "Study Area", with small portions of the Study Area being specified as priority areas for remediation. The Study Area boundary is defined by the upper Clear Creek drainage basin boundary shown on Figure 1-1. Major drainages in the Study Area include the North, West, and South Forks of Clear Creek, and Chicago Creek drainages. U.S. Highway 6 follows the main stem of Clear Creek from Golden to the intersection of Highway 6 and Interstate Highway 70 (I-70). Thereafter, I-70 parallels the main stem of Clear Creek to its headwaters near the Eisenhower Tunnel, and State Highway 119 parallels the North Fork of Clear Creek.

The Central City/Clear Creek Superfund Site was placed on the National Priorities List in 1983 because of the deleterious impacts historical mining operations have had on human health and the environment within the Clear Creek basin. Elevated concentrations of metals (cadmium, copper, iron, manganese and zinc, and others) in the Clear Creek basin were the driving factors in the listing of the site.

The U.S. Environmental Protection Agency (EPA) and the Colorado Department of Public Health and Environment (CDPHE) work as a team on the Site, with the CDPHE acting as the lead agency in recent years. The EPA and CDPHE have published three Records of Decision for a variety of remedial actions under Operable Units (OUs) 1,2, and 3. Remedial Actions have included removal or containment of waste piles, slope stabilization, run-on and runoff controls, collection and piping of tunnel discharges, and chemical treatment of the Argo Tunnel discharge.

SECTION 2

SITE HISTORY AND ENFORCEMENT ACTIVITIES

2.1 SITE HISTORY

The Central City/Clear Creek Superfund Study Area is located on the east slope of Colorado's Front Range. The Colorado Mineral Belt transects the Study Area indicating the rich mineralization of the area. Metals such as gold, silver, copper, lead, and zinc were mined from the area.

Due to the rich mineralization of the area, the Clear Creek mining district became one of the most heavily mined areas of Colorado. There are well over 800 inactive mines and tunnels in Clear Creek and Gilpin Counties. Historically, it is estimated that over $110 million worth of mineral production, in "1900" dollars, occurred within the district. Gold and silver accounted for the vast majority of the mining interest.

Mining Activity in the area commenced in 1859 with placer gold being found at the mouth of Chicago Creek, and the first lode discovery occurring in Gregory Gulch later that year. By the summer of 1860, almost all surface lodes had been claimed.

Extraction of surface ores led to an increase in the depth of mining. This increase in depth brought problems with water drainage, and miners began to encounter more durable sulfide ores that could not be milled with the same ease as the oxidized surface ores. To compensate for these problems, drainage tunnels were constructed and new milling techniques were developed.

Today, most of these mine drainage tunnels are still functioning and discharge acid mine water which contains high concentrations of heavy metals. Mine tailings from milling operations and waste rock from the development of the mines are present at numerous locations throughout the Site.

In September 1983, the Site was selected for addition to the Superfund National Priorities List due to the presence of heavy metals in the environment. Since that time, the Environmental Protection Agency (EPA) and the Colorado Department of Public Health and Environment (CDPHE) (formerly Colorado Department of Health) have conducted studies and have made decisions on cleanup alternatives for certain areas. These decisions are discussed in greater detail in Section 4.0.

Three removal actions were conducted at the Study Area by EPA's Emergency Response Branch. In March 1987, a removal action was initiated at the Gregory Incline to prevent the collapse of the mine waste pile. A collapse would have allowed the mine waste to slide into The North Fork of Clear Creek, and EPA was concerned that a large load of metals-laden mine waste would wash downstream into Clear Creek and contaminate the municipal water supply of the City of Golden, Colorado. As part of the removal action, EPA removed an old deteriorated wood crib retaining wall, decreased the slope of the mine waste pile, and constructed a gabion basket retaining wall. In Fall 1987, a removal action was initiated in the Idaho Springs area. This removal action involved connection of residents to the City of Idaho Springs water supply. Prior to the removal action the residences had been served by private ground water wells which contained elevated concentrations of cadmium. In August 1991, a removal action was initiated approximately 1/4 mile north of Idaho Springs. This action involved removal of mercury from a small trailer. The mercury and a small amount of soils were placed in a ten gallon steel drum and shipped to a mercury recovery facility.

2.2 ENFORCEMENT ACTIVITIES

A potentially responsible party search was conducted as part of the earlier investigations at the Site. The search revealed information on the ownership of the five discharging mine tunnels and five mine waste piles. However, further research was needed; as a result, research continues.

If information indicates it is appropriate, Notice Letters will be sent to potentially responsible parties (PRPs), information gathering may occur pursuant to Section 104(e) of CERCLA, and Liens may be recorded against specific parcels of property.

EPA does not believe that remedial action at the site should be delayed pending finalization of the search and is proceeding with the Record of Decision. As they are identified, the status of potentially responsible parties will be evaluated. If appropriate, EPA will notify potentially responsible parties (PRPs) of the selected remedy and will initiate negotiations for the recovery of costs and/or implementation of the remedy. If the PRPs do not commit to payment of costs, and/or performing the remedy in a timely manner, EPA may proceed with a fund-financed remedial design and remedial action. If it is determined that a PRP has little or no liability for the contamination at the Site, this information will be used to determine if a fund-financed remedial action will be initiated. A fund-financed remedial action would use Federal and State monies to perform the cleanup.

SECTION 3

COMMUNITY PARTICIPATION

Community involvement efforts for OU4 included meeting with Upper Clear Creek Watershed Association and individual members or stakeholders to obtain input in shaping the scope of work and to understand the community concerns as OU4 work progressed.

The Clear Creek Watershed Advisory Group, which was funded in part by EPA technical advisory grants, was also instrumental in advising the agencies on local interests, priorities and opinions. The Watershed Advisory Group issued their final report in January 2001. The Watershed Advisory Group final report is a reference that summarizes the status of many aspects of the site from an interested stakeholder's viewpoint and was relied on by the Agencies in assessing local opinion regarding many aspects of the site.

During 2000 CDPHE staff met with a number of watershed stakeholders to obtain input and advice on formulating the focus of OU4. CDPHE obtained input from other groups including the Black Hawk Rotary Club in December 2002, the Clear Creek County Commissioners, and the Golden City Council.

Presentations were made to Gilpin County Commissioners in January 2001 and February 2002 regarding the proposed mine waste repository, in February 2002 regarding the Remedial Investigation and preliminary cleanup alternatives and then on August 3rd, 2004, regarding the Feasibility Study and Proposed Plan.

Formal presentations were made to the Upper Clear Creek Watershed Association in August and November 2002 regarding the Remedial Investigation, Fall 2003 presenting alternative modeling results and Feasibility Study preview, and June 10, 2004 presenting Feasibility Study and proposed plan options. The proposed plan was issued July 23, 2004. CDPHE and EPA accepted public comments from July 23, 2004 to August 23, 2004. A public meeting was held on August 11, 2004 to explain the proposed cleanup alternatives within the proposed plan, and to accept public comment on the proposed plan.

Fact Sheets were produced to solicit public input in November 2000 (general site update and to solicit input on OU# 4), February 2002 (mine waste repository) and April 2003 regarding potential remedial alternatives for North Fork of Clear Creek OU#4 clean up components.

SECTION 4

SCOPE AND ROLE OF OPERABLE UNIT

As with many Superfund sites, the problems at the Central City/Clear Creek Study Area are complex. To effectively address some of these problems, EPA organized work at the Site into separate working units known as Operable Units (OUs). The Central City/Clear Creek Superfund Study Area was organized into three Operable Units which were designated to address heavy metals contamination associated with historic mining activity in the Clear Creek drainage basin. A brief description of the three Operable Units is provided below.

Operable Unit #1:

- Treatment of the discharge from Argo, Big Five, Quartz Hill, Gregory Incline and National Tunnels with passive treatment (constructed wetlands).

  STATUS: Treatability Studies of passive treatment was done by the Colorado School of Mines at the Big Five Mine Tunnel. Full scale application of passive treatment has not been implemented at any of the five tunnels. The OU #1 ROD was amended by the OU #3 ROD.

Operable Unit #2:

- Tailings/waste rock piles associated with the OU 1 Tunnels.

  STATUS: Response Actions including slope stabilization, capping, run-on and run-off controls, and/or mine waste removal are complete at all but Quartz Hill mine waste pile.

Operable Unit #3:

- Further investigation expanded the list of tunnels and tailings/waste rock piles to be addressed, and amended the OU 1 ROD by specifying the following:

  - Treatment of the Argo Tunnel discharge with chemical precipitation

  - Addressing the Burleigh Tunnel discharge with passive treatment

  - Assessment and collection of ground water in the Idaho Spring area (Virginia Canyon)

  - Capping, or other controls at certain mine waste piles (Gregory Gulch piles #1 and #2, Clay County, Boodle Mill, McClelland tailings, North Clear Creek tailings, Chase Gulch #1 and #2, north side of Quartz Hill, Golden Gilpin, Black Eagle, Little Bear). As a part of capping and controlling mine waste piles, CDPHE and EPA have been taking efforts to establish a site-wide mine waste repository.

  - Residential water well assessment and alternate drinking water supply.

- N Selecting the use of the interim waiver of applicable or relevant and appropriate requirements for the discharge from the Big Five Tunnel.

- N Collecting the discharges from the Gregory Incline, National and Quartz Hill Tunnels.

- N Delaying a decision on treatment of the Gregory Incline, National and Quartz Hill Tunnels pending further delineation of the contamination sources in the North fork of Clear Creek. These studies have served as the basis for Operable Unit #4 (OU4).

STATUS: All response actions under OU3 are complete except the following: remediation of the Chase Gulch #2 mine waste pile, remediation of the Golden Gilpin tailings pile, Virginia Canyon ground water treatment at the Argo Water Treatment Plant, and establishment of the site-wide repository. Passive treatment was not used to address the Burleigh Tunnel discharge. Instead the OU3 ROD was amended to identify No Action as the selected remedy for addressing the Burleigh Tunnel discharge.

Operable Unit #4:

Operable Unit 4 is identified as the basin, or watershed, of the North Fork of Clear Creek. The Remedial Actions selected in this Record of Decision are intended to improve water quality in the North Fork of Clear Creek (defined as Segment 13b CDPHE's Water Quality Control Commission) and its tributaries to meet a level of water quality which would enable the North Fork to support a brown trout population.

Another intended result of implementing the selected Remedial Actions is to reduce the level of impact that the North Fork has on the water quality in the main stem of Clear Creek so that remedial action objectives are met for the reach of the main stem of Clear Creek between its confluence with the North Fork and the City of Golden (Segment 11).

Remedial actions at tailings and waste rock piles are intended to reduce the amount of metal-laden runoff from waste piles that contaminates the North Fork of Clear Creek and its tributaries. Doing so will reduce the ecological threat associated with exposure to contaminated surface water and sediment. Remedial actions at tailings and waste rock piles are also intended to reduce human health risk that is associated with exposure to waste rock piles.

Ground water quality will be protected through run-on and runoff controls and capping of tailings/waste rock piles. Ground water within Gregory Gulch will be collected for treatment in order to mitigate its effect on in-stream water quality.

Components of the remedy selected for OU 4 include:

- Capping/Removal of priority Tailings/Waste Rock Piles in the North Fork of Clear Creek drainage;

- Treatment of discharges from the Quartz Hill, Gregory Incline and National Tunnels;

- Collection and treatment of the drainage/ground water in Gregory Gulch;

- Sediment Control in the North Fork of Clear Creek and its tributaries.

SECTION 5

SITE CHARACTERISTICS

The Clear Creek/Central City Superfund Study Area covers the approximately 400 square miles Clear Creek watershed, located in the Front Range of the Colorado Rocky Mountains. The basin of the North Fork of Clear Creek encompasses approximately 60 square miles of this study area, and has been designated as Operable Unit four (OU4) of the Clear Creek/Central City Superfund Site. OU4 encompasses the North Fork of Clear Creek and its tributaries (segment 13b) and the main stem of Clear Creek from the confluence with the North Fork to the city of Golden, CO (segment 11) (Figure 5.1). OU4 consists of highly variable mountainous terrain characterized by steep-walled canyons and narrow valley floors. Cities within OU4 are Central City and Black Hawk. These cities have experienced accelerated development since the introduction of gambling in 1991.

Elevated metals concentrations are the risk drivers within OU4. The metals, or contaminants, of concern for aquatic life are zinc, copper, cadmium, and manganese, and of concern for human health are lead and arsenic. The majority of these metals pose acute or chronic threats to aquatic organisms which are more sensitive to their high concentrations than are humans. The risk to human health due to exposure to mine wastes is low, but is associated with ingestion of waste rock and inhalation of waste rock dust. Ecological risk is the primary driver of cleanup actions at OU4 and is mainly associated with direct exposure to metals-contaminated surface water.

In addition to the deleterious effects of mine wastes, the areas of poor fish habitat along the North Fork also threaten the survival of trout species. In some places the valley through which the North Fork flows has been severely narrowed due to historic mining and recent development. This has resulted in the channelization of the river and a decrease in the amount of pools, riffles, and stream bank vegetation that is necessary to provide thriving fish habitat.

5.1 GEOLOGY

The North Fork basin lies within a terrain of Precambrian crystalline rocks, which constitute the core of Colorado's Front Range. The rocks are interlaid and consist of gneiss, granite, schist, and pegmatite. Microcline gneiss with interlaid biotite gneisses and pegmatite are the dominant rock units, and they generally form the walls of the ore deposits. Several other varieties of felsic and intermediate rocks occur locally. The Precambrian crystalline rocks are folded along northeast-trending axes. The folding axes plunge gently either to the northeast or the southwest. The dominant structure in the area is the Central City anticline that bisects much of the basin. Abundant, closely spaced and intersecting faults cut the bedrock. Most of the faults dip steeply and have dominant strike-slip displacement (Sims and Gable 1964a).

Many Tertiary-age small dikes, veins, stocks, and plutons of igneous rocks cut the Precambrian bedrock. The most common of the Tertiary rocks are leucocratic granodiorite porphyry, quartz monzonite porphyry, and quartz bostonite porphyry (Sims et al., 1964b). The Tertiary intrusives are the source of sulfide ores that contain deposits of precious metals (gold and silver) and base metals (iron, copper, lead, nickel, and zinc; as well as small quantities of cadmium and manganese). The veins and stockworks that constitute the ore deposits were formed largely as fillings in faults. The common metallic minerals are pyrite (FeS_2), sphalerite (ZnS), chalcopyrite ($CuFeS_2$), tennanite (CU_3AsS_3), and galena (PbS). Gold occurs in the free state and in the structure of metallic vein mineral. Silver occurs in discrete sulfosalts and more commonly is in the structure of metallic minerals (Sims et al., 1964b).

The Central City/Black Hawk area is not considered to be seismically active. Earthquakes have occurred in the region, but have been mild with only slight damage occurring in localized areas (RMC, 1992).

5.2 SURFACE WATER HYDROLOGY

The headwaters of the North Fork begin at an elevation of approximately 11,100 feet above sea level near Kingston Peak. From its headwaters, the North Fork flows approximately 17.3 miles down to the main stem of Clear Creek. The elevation at the mouth of the North Fork is approximately 6,900 feet above sea level.

The major tributaries to the North Fork include Gregory Gulch, Russell Gulch, and Nevada Gulch. The flow rate of these tributaries, as well as the North Fork itself, varies dramatically with the seasons. Low flow conditions for the North Fork generally extend from October through March and have an average flow rate of 4.4 cubic feet per second (cfs). Snowmelt runoff occurs between mid-April and mid-July, and peak flow normally occurs in late May or early June. The average peak flow rate is approximately 134 cfs. The monsoon season occurs from about mid-July through August. The flow rates during the monsoon season generally range from 9.4 cfs to 28.7 cfs, and have an average of approximately 17.4 cfs. Low flow conditions are used to describe general conditions from September through April, and high flow conditions are considered to occur from May through August (this includes snowmelt runoff and monsoon flow conditions).

Historical mining activities have enhanced the formation of acid mine drainage by bringing large volumes of metals-bearing material to the surface, and by providing avenues for water and oxygen to enter the subsurface. Acid mine drainage from waste rock and tailings piles and discharges from tunnels are the primary sources of metal contaminants and acidity. Both point and non-point metal loading sources to surface waters within the North Clear Creek basin were evaluated in the Remedial Investigation for OU4, and conceptual models of the loading sources under different flow regimes were developed (RMC, 2002b). The conceptual models for lowflow, average high-flow, and very high-flow conditions are shown on Figures 5.1, 5.2, 5.3, respectively.

The Gregory Incline contributes the largest point source metals load to the North Fork of Clear Creek under low-flow conditions (Figure 5.1). The Gregory Incline has relatively consistent flow and metal concentrations throughout the year, so its impact on the North Fork is more pronounced during low-flow than during high-flow. The next largest point source of metals load during low-flow is Gregory Gulch, which is then followed by the Quartz Hill Tunnel and the National Tunnel. The majority of the Quartz Hill Tunnel discharge seeps into the subsurface and is incorporated into the Gregory Gulch ground water. Combined, the discharging tunnels contribute about sixty percent of the metals load to the North Fork of Clear Creek during lowflow. Non-point source loads, such as ground water inflow and metals release from sediments, as well as flow from other tributaries including Chase Gulch and Russell Gulches, comprise the remaining forty percent of the low-flow loads.

Under spring runoff conditions (mid-May to mid-July), the relative contribution of metals from the Gregory Gulch and Russell Gulch tributaries increases. Combined, these gulches account for approximately two-thirds of the total loading, with Gregory Gulch contributing about twice the load of Russell Gulch (Figure 5.2). However, in years with very high-flows, such as occurred in spring 1995, the percentage of loading coming from Russell Gulch surpasses that from Gregory Gulch and all other sources (Figure 5.3). During the spring runoff, mine waste sediments are transported from Gregory and Russell Gulches into North Clear Creek where they subsequently contribute to non-point source loading year round.

The North Fork of Clear Creek contributes a significant metal load to the main stem Clear Creek year-round. The following table provides a comparison of the average loads of the contaminants of concern (COCs) to aquatic life at the mouth of the North Fork of Clear Creek to the loads in Clear Creek upstream at Kermits. This comparison is made using data collected after the Argo Water Treatment Plant became operational in April 1998. Both low- and high-flow data are compared.

Metal[2]	**Flow Regime**	**Average Load in Pounds/Day**[1]		**North Fork's Relative Contribution to Clear Creek**[3]
		Clear Creek at Kermits	**North Fork at Mouth**	
Zinc	High	400	199	33%
	Low	119	56	30%
Copper	High	19.4	8.2	32%
	Low	4.9	1.2	19%
Cadmium	High	2.04	0.68	25%
	Low	0.56	0.20	27%
Manganese	High	483	282	37%
	Low	165	115	41%

Notes:

1. RMC(2004).
2. Data from TDS (2002).
3. All metals dissolved.

5.3 GROUND WATER

On a regional scale, the geology of the crystalline bedrock is the primary controlling factor in the occurrence and movement of ground water. Structural features such as faults and fractures within the metamorphic and igneous rocks influence water levels and flow directions. Also, the complex network of mine workings, shafts, and tunnels throughout the area provide preferred ground water flow paths.

Ground water is located in both bedrock and alluvium. Bedrock ground water is used as a drinking water source and consists of numerous unconfined aquifers. In the mountainous terrain of the Study Area the water quality is highly variable. Bedrock aquifers are highly fractured and difficult to characterize. Since there is limited well and ground water data, the full extent of ground water contamination within the North Fork basin was not determined.

Bedrock ground water is known to extend several hundreds offset below ground surface, but information on depths is not available because most bedrock wells have only been completed into the upper tens of feet of the bedrock. The fact that numerous tunnels have been advanced to dewater underground mine workings indicates that bedrock ground water is found at depths of at least 2,000 feet below ground surface. Bedrock ground water is unconfined in the upper portion, but could be under confined conditions at greater depths.

Depths to ground water within alluvial materials vary depending on the proximity to the North Fork. For example, the depth to ground water within the floodplain of the North Fork may be as little as three to five feet, increasing to 10 to 15 feet at the limits of the floodplain. The depth to ground water in the alluvium of tributaries may be greater, which is the case near the Quartz Hill Tunnel where the depth to ground water approaches 30 feet (CDM, 1987,1990)

SECTION 6

CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

This section discusses the current and reasonable anticipated future land uses and current and potential beneficial ground and surface water uses in OU4. This information forms the basis for risk characterization conclusions presented in Section 7.

6.1 LAND USES

Current land uses within OU4 include residential, recreation, and to a limited extent, agriculture and ranching. The Clear Creek watershed is a popular outdoor recreation area for residents along the Front Range. Popular activities include hiking, camping, and ATV riding. The majority of the land within OU4, not including the Black Hawk and Central City areas, has a forestry zoning designation, which is a broad designation that does not preclude development of the land for residential or commercial use. Based on discussions with Gilpin County planning officials future land uses within OU4 could potentially include residential and commercial use in addition to the current uses of the land.

6.2 SURFACE WATER USES

As mentioned above, the Clear Creek watershed is a popular recreation destination. Recreational surface water uses within the North Fork basin (OU4) include fishing, swimming, gold panning, and recreational mining. Based on the relative low flow of the North Fork compared to the main stem of Clear Creek, as well as the confining nature of the valley through which the North Fork flows, future uses of the surface water within OU4 are not expected to change.

6.3 GROUND WATER USES

Ground water within OU4 is currently used as a drinking water source for residents who live outside of the Black Hawk or Central City boundaries where connections to municipal water supplies are not feasible. These residents are scattered throughout the OU4 basin or clustered in very small towns within Nevada and Russell Gulches. Unconfined bedrock aquifers supply this drinking water. These aquifers often occur in highly fractured bedrock zones, making ground water characterization difficult. Future uses of ground water as a drinking water source may increase if the population utilizing ground water wells increases. However, the types of ground water use within the Study Area are not expected to change in the future.

SECTION 7

SUMMARY OF SITE RISKS

A Phase II Risk Assessment (CDM 1990) was conducted to evaluate potential human health and ecological risks associated with the existing contamination within the Clear Creek Study Area if no action is taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. The risk assessment determined the ecological risk to be greater at the study area than human health risk. Therefore, human health risk is not discussed in detail in this record of decision. The following sections discuss the exposure pathways and contaminants of concern separately for the human health and ecological risk assessments that were addressed in the Phase II risk assessment.

7.1 HUMAN HEALTH RISK ASSESSMENT

7.1.1 Identification of Contaminants of Concern

Historic mining, milling, and smelting operations typically contaminated the environment with a number of metals. This includes many of the metals which were the main objective of historic mining and refining activities (copper, lead, silver, zinc), as well as a variety of other metals that exist in the ore body (arsenic, aluminum, cadmium, chromium, fluoride, iron, manganese, mercury, nickel). Essentially, all of these chemicals occur at elevated concentrations (compared to background) in on-Site media (including soil, mine wastes, surface water, and ground water). Even though many metals occur at elevated concentrations within the Clear Creek watershed, the results of preliminary calculations at this site indicate that arsenic and lead pose the majority of human health risk at the site and are, therefore, considered the contaminants of concern to human health.

7.1.2 Exposure Assessment

The exposure assessment identifies scenarios through which people could contact COCs in site media and estimates the extent of exposure. Human exposure was evaluated based on current and future residential uses. The exposure pathways that were identified are discussed below for each exposure medium for which monitoring data are available.

<u>Surface Water/Sediment</u>

Current surface water uses in the Clear Creek Study Area include kayaking, tubing, swimming, irrigation, and drinking water. Residents or vacationers to the Study Area could be exposed to chemicals in surface water via incidental ingestion of surface water while swimming, kayaking, or tubing; or via ingestion of surface water used as drinking water. Dermal absorption of metals from water or sediment is considered to be negligible. However, dermal contact with low-pH water, such as mine adit water, could result in skin irritation. Exposure to surface water/sediment is not expected to vary under future use conditions.

<u>Fish</u>

Clear Creek is used as a fishing area by residents and vacationers, and it assumed that the fish that are caught are kept and eaten. Persons ingesting fish from Clear Creek could be exposed to COCs if any of the metals accumulated in the fish. Therefore, exposure via ingestion offish caught in Clear Creek is possible. Exposure to chemicals in fish is unlikely to vary under future use conditions.

Ground water

Ground water in the Clear Creek study area is used to some extent to provide drinking water and/or water for other consumptive uses. Potential exposures from wells associated with waste rock are evaluated assuming that in the future domestic wells could be placed in these areas if the waste rock is removed. Residents using ground water as a drinking water source could be exposed via ingestion to COCs present in the ground water. None of the COCs are volatile or likely to be dermally absorbed. No other ground water use exposure pathways exist under current or alternate future use conditions.

Tailings/Waste Rock

Individuals could be exposed to chemicals in tailings or waste rock by direct contact and incidental ingestion of these materials and via inhalation of wind-blown dust. Dermal absorption of metals is not likely to result in significant exposure. Exposure potential is greatest for resident children who play on tailing/waste rock piles, as well as workers who are exposed to tailings when developing mine waste piles for residential or commercial/industrial uses. Exposure to chemicals in tailings/waste rock is not expected to vary in the future.

Air

Individuals living, working, or vacationing in the Clear Creek study area could be exposed via inhalation of chemicals in dust resulting from wind entrainment for tailings/soil particles or in dust generated by human activities. Exposures are likely to be greater for residents than for workers or vacationers because residents are likely to be exposed more frequently and for a greater period of time. Only exposure of Central City residents were evaluated because this was the only area for which air concentrations were measured.

7.1.3 Toxicity Assessment

The purpose of a toxicity assessment is to review and summarize the potential for each COC to cause adverse effects in exposed individuals. This is determined by combining the exposure (intake) of the contaminant with toxicity data for the contaminant. Toxicity data is developed for assessment of carcinogenic and noncarcinogenic (systematic) health effects. For carcinogens, this toxicity data is known as a cancer slope factor (CSF) in units of risk per milligram of chemical per kilogram of body weight per day (mg/kg-day-1). CSFs are defined as the statistical 95% upper confidence limit on the slope of the dose-response relationship at low doses for a carcinogen. Dose-response relationships are determined from experimental data obtained from laboratory animals; this data is then extrapolated to human beings. The chemical-specific CSF is multiplied by the estimated daily chemical intake to provide an upper-bound estimate of the increased likelihood of cancer resulting from exposure to the chemical. This risk would be in addition to any "background" risk of developing cancer over a lifetime due to other causes. EPA considers remedial action at a site when estimated total excess cancer risk to a current or future population exceeds one in ten thousand (IE-4). Depending upon site-specific characteristics, EPA may also consider remedial action at a site when estimated total excess cancer risk ranges between one in ten thousand (IE-4) and one in one million (IE-6).

For non-carcinogens, the risk level is presented as a ratio of exposure (intake) to the reference dose (RfDs) for each contaminant for a given exposure pathway. The reference dose represents the daily exposure to a chemical that would be without adverse effects, even if the exposure occurred continuously over a lifetime. Risk levels that are less than one (chemical exposures that are less than the RfD) are not likely to be of concern even to sensitive individuals. Risk levels that are greater than one (chemical exposures that are greater than the RfD) indicate a possibility for adverse effects. Risk levels are combined with assumptions regarding exposure factors such as exposure rate, frequency, and duration, to calculate a target concentration for each chemical for a given pathway. Target concentrations are compared with measured or estimated chemical concentrations to evaluate potential risks.

EPA has not published toxicity data for lead because of the increasing concern over its effects at low concentrations. Lead is a carcinogen at high concentrations, but of greater concern is the effect that lead has on the central nervous system at lower concentrations. Lead has been shown to cause learning disabilities and brain damage in humans at low concentrations in the blood. The recommended risk threshold for lead levels in the blood is 10-15 micrograms/deciliter.

Instead of evaluating lead risk using typical intake calculations, EPA has developed other methodologies for evaluating lead exposures. One such methodology is the Integrated Exposure Uptake Biokinetic (IEUBK) model, a computer model used to predict blood-lead levels in children exposed to lead from a variety of sources, including soil, dust, ground water, air, diet, lead-based paint, and maternal blood. Estimated blood-lead levels are compared to target bloodlead concentrations to assess possible risks. The IEUBK model is intended for use only for children up to the age of seven, as these are the most sensitive receptors to lead exposure. The model assumes daily exposure in a residential setting. The IEUBK model was used at the Site, along with EPA guidance (Office of Solid Waste and Emergency Response Directive 9355.4-02), which recommends that lead concentrations in soil be cleaned up to an action level of 500-1000 milligrams/kilogram in mine waste piles. The OU3 ROD identified the levels of concern for lead and arsenic concentrations to be greater than 500 mg/kg and 130 mg/kg respectively. In order to maintain similar levels among operable units within the Study Area, these lead and arsenic concentrations will be used as the risk threshold values at OU4. The action level of 500 milligrams/kilogram of lead was selected under OU3 because, based on data collected at the Site, this concentrations would ensure that approximately 95% of all people exposed under the maximum reasonable exposure scenario would maintain blood lead levels below 12.5 micrograms/deciliter. The 500 milligram/kilogram action level for lead is also consistent with the range specified by EPA guidance.

7.1.4 Risk Characterization

The Phase II Risk Assessment characterized risks to current and future human populations of concern, consisting of the resident, vacationer, and worker. The risk characterization process was performed to estimate the likelihood and nature of the potential effects to human health that may occur as a result of exposure to the COCs at the site. Results of the risk characterization provided the risk managers with information regarding the potential need for remediation at the site. The human health risks associated with each media are discussed below.

<u>Surface Water</u>

Surface water at the Clear Creek study area is not expected to present a risk to human health from ingestion or recreational use based on the exposure scenarios evaluated in the risk assessment. Ingestion of water from mine drainage tunnels and, in some cases, water in their immediate proximity could pose a risk to human health. However, this exposure scenario was not evaluated in detail because it is not considered to be a reasonable exposure scenario.

<u>Ground water</u>

The results of the domestic well sampling program, conducted as part of the Phase II Risk Assessment (CDM 1990), indicate that only one drinking water well (located in the Virginia Canyon area) exceeded primary drinking water standards (cadmium exceeded) and health based criteria (manganese exceeded). This well is not currently being used for drinking water. In four drinking water wells (located along the main stem of Clear Creek), arsenic was below the primary drinking water standard, as well as the MCL of 10 µg/L, but was present in concentrations that present a potential excess risk of cancer ranging from 2 cancer incidences per 10,000 people to 7 cancer incidences per 100,000 people.

The results of the ground water samples taken from the 19 monitoring wells indicate that along the Clear Creek main stem, the alluvial ground water in or near tailings and waste rock piles had concentrations of cadmium, copper, fluoride, manganese, and zinc that could pose noncarcinogenic risks to human health if used as a drinking water supply.

In the North Fork of Clear Creek, bedrock and alluvial ground water had concentrations of cadmium, manganese, and zinc which could pose noncarcinogenic risks if used as a drinking water supply. Arsenic concentrations in this area had an associated potential excess cancer risk of 9 cancer incidences per 100,000 people for alluvial ground water and 7 cancer incidences per 100,000 people for bedrock ground water.

This data indicates that based on location and the specific metal concentration of a given well, it is possible that a ground water well could pose a human health risk. The ground water pathway to humans via residential wells is addressed under OU3 rather than OU4.

<u>Air</u>
Air sampling to determine the human health risks associated with the inhalation of metal-laden air was conducted at Central City. Central City was chosen because of the large volume of the mine waste and the relatively dense population in this portion of the study area. Comparing the risk-based target concentrations to the concentrations measured under the average and maximum plausible exposures indicates that there is a potential risk to human health (CDM 1990). The combined excess carcinogenic risk range for inhalation of all contaminants is 4 cancer incidences per 100,000 people and 9 cancer incidences per 100,000 people for the average and maximum exposure scenarios, respectively. The greatest proportion of total inhalation excess cancer risk is attributed to chromium.

<u>Mine tailings/waste rock</u>
The Phase II risk assessment evaluated the potential risk to human health from incidental ingestion of mine waste throughout the entire Clear Creek watershed, and not specifically on the risks associated with mine waste piles within the North Fork sub-basin. Therefore, it does not contain specific data on the risks associated with the OU4 waste piles. However, the exposure pathways and receptors (i.e. residents), as well as the mineralogical characteristics of the waste piles, are identical at the main stem and the North Fork of Clear Creek. Therefore, it is inferred that the risks posed to human health along the North Fork are similar in nature and magnitude to the risks associated with waste piles along the main stem of Clear Creek. A summary of the surface composite data that was collected at the various mine waste piles within the Clear Creek watershed can be found in the Phase II risk assessment (CDM 1990). A review of the data shows that both arsenic and lead would be expected to occur in some of the OU4 mine waste piles at concentrations which could pose a potential risk to human health.

Ingestion of Fish

The risk associated with ingesting fish caught within the study area was evaluated. The results show that mercury and cadmium levels in the fish tissue are well below the risk-based target concentrations (CDM 1990). Therefore, ingestion offish from Clear Creek does not appear to present a risk to human health. It should be noted that cadmium and mercury were specifically evaluated because, with the exception of zinc, these two contaminants accumulate in fish to a greater degree than the other contaminants of concern. Because of zinc's low toxicity to humans, it is unlikely to pose a threat to human health.

7.1.5 Evaluation of Risk from Lead

The Phase II risk assessment used the IEUBK model to estimate blood lead levels for child residents exposed to lead in soil and mine waste piles. The model estimated potential blood lead concentrations of approximately 22 µg/dl to over 30 µg/dl for the maximum plausible exposure case (CDM 1990). These potential blood lead levels can be compared with the 10-15 µg/dl range of concern identified by EPA (1988c). Based on this comparison, it appears that adverse effects in children exposed to lead could occur under the exposure conditions evaluated for the Central City area of the Clear Creek study area. The highest potential risk would be from lead contaminated soil and dust ingestion; the contributions of inhalation exposure and drinking water exposure to the total risk are quite low.

7.1.6 Human Health Risk Summary

Risks to human health are not expected from ingestion of surface water (based on municipal diversions) when used as drinking water, ingestion of surface water while swimming, and ingestion of fish based on the exposure scenarios evaluated in the risk assessment. There are potential risks associated with ingestion of ground water, incidental ingestion of tailings, and inhalation of airborne dust. Arsenic contributes most significantly to potential risks from ground water and tailings. All the chemicals evaluated for the inhalation pathway pose potential risks to human health. Lead exposures from ingestion of soil and dust pose potential risks to children.

OU4 remedial action will reduce the potential for human exposure through the capping and stabilization of certain mine waste piles. Potential exposure during remedy implementation will be limited by use of conventional dust control measures during activities which have the potential to disturb mine waste and create dust.

7.1.7 Assessment of Uncertainties

Sources of uncertainty associated with the Phase II risk assessment include:

- Exposure assumptions (e.g. pathways, frequency, and duration),
- Limited number of samples from which to determine exposure point concentrations,
- Varying mineralogical nature of the soils within the study area making background determination difficult
- Incomplete characterization on the toxicity of different ionic forms of metals or an inability to incorporate such information into a risk assessment
- Uncertainty in assessing the toxicity of a mixture of chemicals

7.2 ECOLOGICAL RISK ASSESSMENT

7.2.1 Identification of Contaminants of Concern

The Phase II risk assessment identified the impact of mine waste contamination on aquatic organisms within the Clear Creek Study Area. The contaminants evaluated included aluminum, arsenic, cadmium, chromium, copper, fluoride, lead, manganese, nickel, silver, and zinc. Further assessment has lead to a refinement of this initial list to the following chemicals of concern to aquatic life: copper, zinc, cadmium, and manganese.

7.2.2 Exposure Assessment

The media of concern in the ecological risk assessment were surface water, including tunnel discharges and leachate from mine waste piles, and stream sediments. Also of concern to the health of aquatic organisms is the potential for storm events.

Aquatic organisms, mainly trout and macroinvertebrates, are the primary populations at risk within the North Fork and main stem of Clear Creek. This is due to their constant direct contact with contaminated surface water and stream sediments, and their low tolerance for metal-contaminated water. The Phase II risk assessment evaluated the potential risk to aquatic macroinvertebrates and to the sensitive fish populations that currently inhabit, or would normally be expected to inhabit, the North Fork and main stem of Clear Creek. The fish species that were evaluated include rainbow, cutthroat, brook, and brown trout. The Phase II risk assessment focuses on trout species because they are important game fish, and are likely to be more sensitive to the COCs than other species of fish. The macroinvertebrates that were most common, and therefore evaluated in the risk assessment were: caddisflies, true flies, mayflies, and stoneflies. The Phase II risk assessment identified the exposure points for these aquatic receptors to be the main stem of Clear Creek and its tributaries, including the North Fork of Clear Creek.

7.2.3 Toxicity assessment

Toxicity values for soft waters have been used in calculating the acute and chronic toxicity of the COCs to aquatic life because the natural hardness of the water in the North Fork is generally low. In general, increased water hardness and alkalinity can reduce the toxicity of some metals to fish and aquatic macroinvertebrates. At the North Fork reference station, the hardness was 30 mg/L (all hardness values in the risk assessment area as CaCOS). Throughout the North Fork, hardness values ranged from 127 to 923 mg/L (EPA 1988a). The background alkalinity in the North Fork was 27 mg/L.

In order to estimate the potential risks to trout and macroinvertebrates due to direct contact with surface water, Toxicity Reference Values (TRVs) are compared to concentrations measured in the North Fork of Clear Creek. TRVs are derived from the results of laboratory studies reported in the literature. Acute TRVs are based on concentrations that have been shown to be lethal to 50% of a test population after short-term exposure. Chronic TRVs for fish correspond to concentrations that have caused adverse effects on reproductive success. Acute and chronic TRVs for the contaminants of concern to aquatic organisms at the study area are found in the Phase II Risk Assessment (CDM 1990).

In the Phase II risk assessment, it was assumed that if the measured chemical concentration is greater than or equal to the TRV (i.e. concentration/TRV $\geq$1.0) then adverse impacts to aquatic organisms may occur. The larger the ratio, the greater the likelihood that impacts may occur. The potential risks to macroinvertebrates and trout species are divided by media and are discussed below.

7.2.4 Risk characterization

The risk to aquatic organisms was characterized by comparing the maximum concentrations of COCs found in surface water, stream sediments, North Fork tunnel discharges, and after storm events to the acute and chronic TRVs for both macroinvertebrates and trout species. If the maximum sampled concentration of a metal is greater than either the acute or chronic TRV, then adverse impacts to aquatic organisms may occur.

7.2.4.1 *Macroinvertebrate risks*

Surface water

Acute effects to macroinvertebrates are expected in the upper portions of the North Fork and Gregory Gulch. TRVs are exceeded for copper at both high and low flow in the North Fork. TRVs for both copper and zinc are exceeded at high flow in Gregory Gulch.

Stream sediments

Potential risks to macroinvertebrates due to contact with stream sediments were not evaluated in the Phase II risk assessment because sufficient toxicity information is not available. However, metal concentrations in sediments were measured at several locations within the North Fork watershed. In general the results indicate that both tunnel discharges and tailings and waste rock piles are increasing the metals load in the sediments immediately downstream of the sources. The benthic macroinvertebrate community was sampled and shown to decrease in abundance and diversity downstream of the contamination sources. Results of solid phase sediment toxicity testing indicate that, in some locations, the sediment is chronically toxic to the macroinvertebrate population (CDM 1990).

Tunnel discharges

The National Tunnel, Gregory Incline, and Quartz Hill tunnel discharge metal-laden water into the North Fork. TRVs were exceeded at each tunnel discharge location. The TRVs for copper and pH are exceeded at the National Tunnel. TRVs for copper, cadmium, zinc, chromium, and pH were exceeded at the Quartz Hill Tunnel. TRVs for chromium and copper were exceeded at Gregory Incline (CDM 1990).

Storm events

Potential risk from storm events depends on the chemical concentrations in surface water and the duration of the exposure. Based on the available sampling results, storm concentrations are generally much higher than the high and low flow values, and potential acute risks to trout and macroinvertebrates are much greater.

7.2.4.2 *Risks to Trout Species*

Surface water

Due to mine waste contamination of surface water, trout are not likely to survive, and trout reproduction is expected to be adversely affected throughout the main stem of North Fork below Black Hawk. TRVs for a number of COCs are exceeded in Gregory Gulch and Chase Gulch as well, indicating the potential for acute effects, as well as impaired trout reproduction, in both of these North Fork tributaries.

In addition to evaluating direct stream concentrations of contaminants, Revised Soil Loss Equation computer modeling of runoff from mine waste piles along the main stem of Clear Creek was conducted to evaluate the impact that contaminated runoff would have on the receiving streams. Though this computer modeling did not include data from waste piles located within the North Fork sub-basin, the results are applicable to this region. In general, the results shown in the OU3 ROD indicate that the majority of the mine waste piles cause an exceedance in State stream standards for very low intensity rainfall events (CDH 1991). For clarity it should be noted that state table value standards have been adopted on many of the stream segments within the North Fork watershed, in these cases the state stream standard is also the Colorado state table value standard. However, when this is not the case the State has set site specific numeric standards which, in general, are greater than state table value standards.

In determining potential risks to aquatic life from ground water that is tributary to surface water, the ground water between Gregory Incline and Russell Gulch was found to have a substantial impact on surface water. The exact location of this ground water impact was not identified during the Phase II Remedial Investigation.

Stream sediments
Arsenic, cadmium, copper, and zinc concentrations were measured in stream sediments along the main stem of North Fork and within Gregory Gulch. The results indicate that one or more of these contaminants pose a potential chronic risk to trout from exposure to stream sediments in the Gregory Gulch as well as the North Fork. These risks are expected to affect trout reproduction and/or early life stages (CDM 1990).

Tunnel discharges
TRVs for multiple metals are exceeded at both high and low flows for the National Tunnel, Quartz Hill, and Gregory Incline discharges (CDM 1990). Based on the comparisons between TRVs and the maximum concentration of metals sampled at these locations, discharge from these tunnels is likely to be acutely toxic to trout.

In addition to the risks associated with metals contamination in tunnel discharges, the Phase II Remedial Investigation identified surge events from mine drainage tunnels as a potential risk. A surge event is defined as a sudden, short-term increase in the discharge of acid mine drainage from a tunnel. Surge events are believed to result from tunnel roof falls which form small dams that can retain water within the tunnel. When sufficient water pressure builds up behind these dams, they can collapse causing a short-term increase in the tunnel discharge. The frequency, duration, magnitude, and potential risk resulting from surge events are not well understood and have not been well documented.

Storm events
Potential risk from storm events depends on the chemical concentrations in surface water and the duration of the exposure. Based on the available sampling results, storm concentrations are generally much higher than the high and low flow values, and potential acute risks to trout and macroinvertebrates are much greater (CDM 1990).

7.2.5 Ecological Risk Summary
Within the North Fork of Clear Creek, there is a clear risk of adverse reproductive effects to trout. Tributaries of the North Fork including Gregory Gulch, Russell Gulch, and Chase Gulch also pose chronic risks to trout. Macroinvertebrates are expected to be severely affected in the main stem of North Fork and Gregory Gulch. Tunnel discharges within the North Fork (Gregory Incline, National Tunnel, Quartz Hill Tunnel) are expected to be highly acutely toxic to trout and macroinvertebrates.

The Ecological Risk Summary is confirmed by Colorado Division of Wildlife monitoring and assessments. No fish have been found in the North Fork of Clear Creek downstream of Black Hawk. The Division of Wildlife has also found that trout populations in the main stem of Clear Creek are less than would be present if metals concentrations were reduced. The Division of Wildlife has suggested remedial activities be focused on lowering metals in the main stem of Clear Creek to concentrations that are lower than current existing conditions, and have particular concerns about zinc and copper levels. (Woodling and Ketterlin, 2001).

Macroinvertebrate sampling has documented the abundance and diversity of macroinvertebrates is lower than would be expected of non-impacted streams for both the North Fork of Clear Creek and the main stem of Clear Creek. Also, consensus-probable effect concentrations developed by EPA as guidelines for concentrations of metal in freshwater sediments historically have exceeded the probable effect concentrations. Sediments from the main stem of Clear Creek have been observed to be generally more toxic than sediments form North Clear Creek. (See RMC 2003 section 2.3.1).

7.2.6 Ecological Risk Uncertainties

In the risk assessment, the evaluation of potential risks to aquatic organisms is based on comparisons of chemical concentrations in water to toxicity reference values (TRVs) for trout and macroinvertebrates. The TRVs are based on laboratory-derived values, thus there is uncertainty in extrapolating these values to field conditions where chemical, physical, and biological factors are different than the laboratory conditions under which the toxicity tests were conducted.

For macroinvertebrates, the lowest toxicity values for a given group (e.g. mayflies) were selected to be protective of that group; however, different species within the group may be present in the study area that differ in sensitivity from the species studied in the laboratory. Chronic toxicity values were only available for pH, therefore, potential chronic risks from the other chemicals could not be evaluated for macroinvertebrates.

Total exposure, and thus risks, to trout may be underestimated because dietary exposures such as the consumption of macroinvertebrates that may bioaccumulate metals, are not evaluated. Insufficient toxicity information is available to evaluate this pathway.

The literature suggests that some degree of acclimation to metals can occur in fish; that is, previous exposure to sub-lethal concentrations of a metal can result in increased tolerance to future exposure to that metal. This assessment does not account for acclimation. The TRVs used in this assessment will overestimate risks for organisms that may be exhibiting acclimation.

Uncertainty is also associated with using total metal concentrations. The total form is expected to somewhat overestimate risks, and EPA has not approved the acid-soluble measurements of metal concentrations. Metal speciation can be important in affecting toxicity, however, methods for analysis of metal species are complex and costly and were not performed for this risk assessment.

SECTION 8

REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) provide a general description of what the cleanup will accomplish. RAOs consist of medium-specific goals for protecting human health and the environment. This section presents the RAOs for surface water, ground water, and waste/tailings piles within the North Fork basin. Included in section 8.2 are the Remediation Goals (RGs), or numeric cleanup values, for each media. RGs are numerical values which represent target contaminant concentrations that the cleanup actions will be designed to meet.

8.1 REMEDIAL ACTION OBJECTIVES

8.1.1 Surface Water Remedial Action Objectives

1. *Reduce in-stream metals concentrations and sediment transport to minimize water quality and habitat impacts and to maximize reasonably attainable water uses of the North Fork of Clear Creek. These actions will also support the survival of a reproducing brown trout population in the North Fork of Clear Creek.*

    Monitoring of the North Fork shows that water quality is significantly impaired. Improvement of surface water quality to a point that is protective of aquatic life is a goal of the OU4 remedy.

2. *Reduce in-stream metals concentrations and sediment transport in North Clear Creek with the purpose of reducing adverse water quality and habitat impacts on the main stem of Clear Creek, to protect aquatic life, and to support a viable reproducing brown trout population in the main stem of Clear Creek.*

    Recent surface water monitoring of the main stem of Clear Creek shows that water quality is still impaired below the confluence with the North Fork, even with the improvements made in the basin. Due, in part, to inflow from the North Fork, aquatic water quality criteria are exceeded in the main stem of Clear Creek, limiting the abundance and diversity of aquatic life populations. The intent of this surface water RAO is to reduce metals concentrations in the North Fork such that State surface water standards can be achieved in the main stem of Clear Creek downstream of the North Fork. However, metals input to the main stem of Clear Creek upstream of the North Fork may limit the effectiveness of the OU4 actions.

3. *Ensure that in-stream metals concentrations do not degrade drinking water supplies diverted from the main stem of Clear Creek.*

    The downstream communities of Golden, Arvada, Westminster, Northglenn, and Thornton divert water from the main stem of Clear Creek below the confluence with the North Fork for municipal uses. Protection of these water supplies is a goal of the OU4 remedy.

4. *Reduce the toxicity to benthic aquatic organisms living at the surface water/sediment interface or in sediment to levels that are protective of aquatic life.*

The U.S. EPA performed sediment toxicity testing on samples in the Clear Creek basin in October 1995, April 1997, and October 1997 as reported in the RI Report (RMC, 2002b). Focusing on the post-Argo Water Treatment Plant data set (i.e., October 1999), the sediment toxicity tests indicated much higher mortality in Clear Creek below the confluence with the North Fork than above.

8.1.2 Tailings/Waste Rock Remedial Action Objectives

1. *Control and/or reduce run-on and runoff from tailings/waste rock piles to minimize generation of contaminated run-off and/or ground water, and to reduce sediment loading of streams.*

   Some tailings and waste rock piles within the North Fork basin have been removed, contained or capped, thereby reducing the exposure to humans, and reducing the potential to generate contaminated run-off or ground water. However, numerous tailings and waste rock piles remain within the basin that are known to, or have the potential to, generate contaminated runoff or ground water that could degrade the water quality of the North Fork. Furthermore, mine waste areas remain within the North Fork basin that are susceptible to wind erosion. The remaining mine waste materials may be acidic and/or possess elevated concentrations of metals. In addition, sediment loading from the piles continues to degrade water quality and habitat in receiving streams and may continue to limit habitat for aquatic life.

2. *Reduce exposure to arsenic and lead from incidental ingestion of surface tailings/waste rock and other mine wastes to minimize the potential threat to human health.*

   The OU3 ROD concluded that incidental ingestion of mine wastes poses a potential risk to human health due to arsenic and lead concentrations. This conclusion was based on analyses performed for the Phase II RI risk assessment (CDM, 1990). Subsequent evaluation of lead in mine wastes confirmed the Phase II risk assessment findings (ATSDR, 1994). Some waste rock and tailings piles have been removed or capped, thereby reducing the amount of exposed areas. Development in Black Hawk and Central City has also covered potential source areas. Although the potential for exposure to metal contaminants has been reduced, waste rock and tailings piles remain that could provide a complete pathway for incidental ingestion.

8.1.3 Ground water Remedial Action Objectives

1. *Control and/or reduce metals loading from ground water to reduce in-stream metals concentrations.*

   Results of surface water monitoring along the North Fork indicate that non-point metal loading occurs through Black Hawk and in select downstream areas. The non-point loads contribute metals and acidity that degrades water quality.

2. *Ensure that contaminated ground water does not adversely impact human health.*

   Limited domestic well sampling identified some single-dwelling drinking water supplies that may pose adverse health risks to humans. Those homeowners were supplied with water treatment systems to treat their well water as part of the OU3 efforts. Limited domestic well sampling identified some single-dwelling drinking water supplies that may pose adverse health risks to humans. Some homeowners were supplied with water treatment systems to treat their well water. An objective of OU4 is to ensure that residents in the North Fork basin have the ability to have the quality of the water produced by their domestic well (or spring) tested, and to be provided with an alternate water source/treatment system should their wells be found to produce water with metallic compounds in excess of the applicable primary drinking water standard.

8.1.4 Air Remedial Action Objective

1. *Control airborne metals contaminants in residential areas.*

Some waste rock and tailings piles have been removed or capped, thereby reducing the amount of exposed areas that could be sources of airborne contaminants. Development in Black Hawk and Central City has also covered areas that were once potential sources. Although the potential for entrainment of metals contaminants has been reduced, exposed waste rock and tailings piles remain that could generate airborne contaminants.

8.2 REMEDIATION GOALS

Remediation Goals (RGs) represent numeric cleanup goals for the remedial action. RGs are established as target concentrations to help meet the remedial action objectives.

8.2.1 Surface Water Remediation Goals

The Water Quality Control Commission (WQCC) divides streams into segments and sets stream standards for each segment individually based on stream use. These standards are based on existing stream conditions, which are the result of historical mining impacts and natural mineralization. These standards along with the Remedial Action Objectives were considered when proposing and selecting the surface water RGs in OU4.

Compliance of remediation goals with surface water standards will be evaluated in two locations: 1) North Fork of Clear Creek from the upstream Black Hawk City limit to the confluence with Clear Creek (WQCC Segment 13b), and 2) Clear Creek below the confluence with the North Fork (lower portion of Segment 11). The evaluation focuses on the ability of the alternatives to meet the surface water standards under both high-flow (spring snowmelt) and low-flow conditions.

Surface water RGs were established for the North Fork below Black Hawk (segment 13b) and the main stem of Clear Creek between the confluence with the North Fork and Golden (segment 11), and are presented in the table below.

Contaminants of Concern	Remediation Goals (µg/L)		
	Flow Regime	**North Fork (Segment 13b)**	**Clear Creek Below North Clear Creek (Segment 11 - lower portion)**
Zinc (dissolved)	High-Flow	381	200
	Low-Flow	675	300
Copper (dissolved)	High-Flow	7.4	5.2
	Low-Flow	15.1	9.2
Cadmium (dissolved)	High-Flow	1.9	1.4
	Low-Flow	3.5	2.3
Manganese (dissolved)	High-Flow	1,531	600
	Low-Flow	2,021	600

The remediation goals for the metals of concern in surface water correlate to Table Value Standards (TVSs), temporary modifications and underlying standards, and Colorado Division of Wildlife (CDOW) research, as shown in the table below.

Contaminants of Concern	Flow Regime	North Fork (Segment 13b)	Main Stem Clear Creek (segment 11 - lower portion)
Cadmium	High-Flow	Table Value Standard (TVS)	TVS
	Low-Flow	TVS	TVS
Zinc	High-Flow	CDOW suggested value	CDOW research-based objective
	Low-Flow	Hardness-based toxicity value	Underlying Numeric Standard
Copper	High-Flow	TVS	TVS
	Low-Flow	TVS	TVS
Manganese	High-Flow	TVS	Concentration calculated by WQCD as of January 1, 2000
	Low-Flow	TVS	Concentration calculated by WQCD as of January 1, 2000

The main stem and the North Fork of Clear Creek are impacted by both mineralization and historical mining. These impacts result in elevated metals concentrations that impair the stream system. Consequently, the water quality standards that are applied to these streams are not the Federal Ambient Water Quality Criteria and State Table Value Standards (TVSs) for all metals. Table Value Standards (TVS) are seasonal hardness-based state-wide stream standards. They are based on aquatic toxicity data and are designed to protect 95% of species present all of the time.

State regulations and procedures recognize ambient conditions with temporary modifications or with standards that are based on monitoring of existing site conditions. In the case of temporary modifications, which are usually employed when there are fairly significant impacts, there will be a more protective underlying numeric standard, which is an underlying goal as set by the WQCC for the specific stream segment. In other instances where monitoring and research show a desired use is currently protected at concentrations different from TVSs, petitioning parties may demonstrate the appropriateness of such alternate standards to the Water Quality Control Commission in lieu of the application of TVSs. The currently applicable standards for Clear Creek include alternate standards for copper and zinc, and for North Fork of Clear Creek include temporary modifications for zinc, copper, cadmium and manganese because of the existing metal concentrations.

Colorado Department of Wildlife (CDOW) suggested values and research-based objective values are based on laboratory aquatic toxicity testing results. These tests evaluate the effects of metal concentrations, both of individual metals as well as the synergistic effects of a combination of metals, on aquatic species. If these results are published, they are often used to determine TVSs.

The hardness-based toxicity value used as the RG for zinc on the North Fork during low flow was calculated using the following equation:

$$\text{Brown Trout Chronic Zinc} = e^{(0.98059 * \ln(\text{hardness}) + 1.402)}$$

The hardness value used in the above equation differs between streams as well as between seasons. Hardness influences the toxicity of certain metals; enabling fish to withstand a larger dose of metals without deleterious effects if the hardness value of the water is high. The average hardness values for the North Fork and the main stem of Clear Creek at high and low flow are given below.

Hardness Values (mg/L as $CaCO_3$)
Used to Calculate Table Value Standards

Segment	High Flow May 1 through August 31	Low Flow September 1 through April 30
Clear Creek Segment 11	53	103
North Fork Segment 13b	80	184

The reasons for using the surface water RG values discussed in this ROD are summarized below for the individual metals of concern to aquatic life.

Cadmium

For cadmium the TVS is the stream standard for both the main stem and the North Fork of Clear Creek at high and low flow.

Zinc

The TVSs (69 µg/L for high-flow and 121 µg/L for low-flow) are lower than the current underlying numeric standards, and are more protective than would be necessary to achieve the RAO of maintaining a reproducing brown trout population in the main stem of Clear Creek. Therefore, the existing underlying numeric value of 300 µg/L will be utilized as the RG for the main stem of Clear Creek during low flow. At high flow, the RAO of maintaining a reproducing brown trout population is currently attained. Therefore the more protective value of 200 µg/L will be used as the RG. This value is suggested by CDOW as an objective of surface water remediation within the Clear Creek watershed, and supported by toxicity testing conducted by CDOW.

A zinc concentration of 675 µg/L is utilized as the low flow RG for the North Fork. This value is based on calculated hardness-based toxicity values from CDOW research for non-acclimated trout (calculates to 675 µg/L at a hardness of 184 µg/L as $CaCO_3$) (Davis and Brinkman, 2003). For high flow, where lower concentrations are more clearly achievable, a somewhat more protective objective of 381 µg/L, as suggested by CDOW, is the RG.

Copper

The main stem of Clear Creek currently has an underlying standard of 17 µg/L; however, this standard is not protective enough to maintain a reproducing brown trout population. Therefore, the TVSs of 9.2 µg/L for low flow, and 5.2 µg/L for high flow are used as remediation goals for the main stem of Clear Creek.

The TVS value of 15.1 µg/L is the RG for the North Fork during low flow. The TVS values of 7.4 µg/L is the RG during high flow. These values are higher than the TVS values for the main stem of Clear Creek because the North Fork has higher hardness values than the main stem of Clear Creek.

Cadmium

For cadmium, the TVS is the stream standard for both the main stem and the North Fork of Clear Creek at high and low flow.

Manganese

Clear Creek Segment 11 (from Idaho Springs to Golden) is classified for water supply use, and several Front Range municipalities divert water from this segment. The WQCC's Regulation No. 38 indicates that, for surface water with a "water supply" classification, the manganese standard is the less restrictive of the: 1) existing water quality as of January 1, 2000, or 2) the Federal SMCL for dissolved manganese of 50 µg/L[1]. Data collected in Clear Creek Segment 11 prior to January 1, 2000 indicate that concentrations of dissolved manganese exceeded the SMCL of 50 µg/L. Consequently, the Clear Creek Segment 11 manganese standard will be the value as of January 1, 2000, when calculated by the WQCD. Discussion with WQCD staff indicates that the standard will be in the range of somewhat less than 600 µg/L to 800 µg/L (Eric Oppelt, WQCD, personal communication, August 20, 2003). A Remediation Goal of 600 µg/L will be used for Clear Creek Segment 11 for both low- and high-flow regimes.

TVS values will be used as remediation goals on the North Fork of Clear Creek. These values are 2,021 µg/L for low flow, and 1,531 µg/L for high flow. These values are greater than the TVS values for the main stem of Clear Creek because of the increased hardness of the North Fork water.

8.2.2 Sediment Remediation Goals

Metals such as zinc, copper and cadmium may accumulate in stream sediments to the point where they impact benthic macroinvertebrate abundance and diversity. This impact may affect the fish population, which relies upon benthic macroinvertebrates, in part, as a food source. The U.S. EPA has developed guidelines for the concentrations of several metals in freshwater sediments, including zinc, copper and cadmium. Based on a review of studies throughout the United States, the U.S. EPA developed consensus-based probable effect concentrations, or PECs, for a variety of contaminants. These PECs represent levels above which harmful effects to aquatic life are likely to be observed. PECs for the three metals of interest are:

Metal	Probable Effect Concentration (mg/kg, dry weight)
Cadmium	4.98
Copper	149
Zinc	459

These concentrations will serve as Remediation Goals for stream sediments in the North Clear Creek Segment 13b and Clear Creek Segment 11.

8.2.3 Tailings/Waste Rock Remediation Goals

The OU3 ROD concluded that incidental ingestion of mine wastes poses a potential risk to human health due to arsenic and lead concentrations. The following remediation levels were used in the OU3 ROD for arsenic and lead in mine waste piles:

- Arsenic = 130 mg/kg
- Lead = 500 mg/kg

These levels will be used as indicators of whether waste rock materials are contaminated. Use of these levels as the remediation goals for the OU4 priority tailings/waste rock piles will assure that the remediation of the identified piles will be completed in a manner that is protective of human health.

8.2.4 Ground Water Remediation Goals

The residents of Central City and Black Hawk are connected to a municipal water supply, and therefore are not at risk from ingestion of contaminated ground water. The remaining areas within the North Fork basin obtain drinking water through the use of groundwater wells or bring water in from other sources. Approximately 60 residential wells in the Study Area were sampled by CDPHE during the implementation of the Clear Creek Alternative Drinking Water Program, which operated between 1994 and 1996 under OU3. Many of the wells sampled were located in the North Fork basin. This was a voluntary program in which residents could have their wells tested for metals at no expense. Bottled water was provided to approximately five residences whose water was shown to exceed the federal or health based standards. These residences were later provided with an alternate water source/treatment system. OU4 does not include specific human health based ground water remediation goals to address residential wells because this was addressed under OU3. If residential wells are found to exceed health based standards, this issue would be addressed and potentially reconsidered as a part of OU3.

There has not been additional ground water sampling in the North Fork basin since the Drinking Water Program. However, based on sample results for the Drinking Water Program and prior sampling of Phase II RI monitoring wells it has been determined that the ground water quality is highly variable at the locations which were sampled, and there is no discernable pattern of contamination; the North Fork basin encompasses a large area of mountainous terrain which contains numerous shallow unconfined aquifers, and numerous fractured bedrock aquifers.

In OU4 Ground water remediation goals are not set at specific numeric values. Rather the goal is to minimize the impact of ground water on surface water in instances where ground water may prevent the surface water remediation goals from being attained. Hence, the surface water Remediation Goals described above are to be considered regarding the impact of non-point groundwater loading on surface water quality.

SECTION 9

DESCRIPTION OF ALTERNATIVES

Remedial technologies potentially applicable to the North Fork remedy were screened with respect to technical feasibility, effectiveness, implementability, and cost in the Preliminary Alternatives Review and Development Report (PARD) (RMC 2003). The screening results are summarized in Table 9.1. Remedial technologies judged to be potentially effective, implementable, and cost effective to remediation within the North Fork basin are identified in the far right column of Table 9.1. These technologies were then assembled into remedial alternatives in the OU4 Feasibility Study (FS) (RMC 2004).

This section provides a brief explanation of the remedial alternatives developed for OU4. The remedial alternatives below were retained after preliminary screening using the nine criteria required by the NCP as part of the OU4 FS. The nine criteria are outlined in section 10 of this OU4 ROD). The alternative numbers used in the FS identify the same alternatives below.

The alternatives remaining after screening were grouped into the following categories:

1. No Action and Institutional Controls
2. Sediment Controls Only
3. Water Collection and Treatment with Sediment Controls

9.1 ALTERNATIVE 1A: NO-ACTION ALTERNATIVE

The no-action alternative is included to provide a baseline against which other technologies can be compared. Implementation of the no-action alternative dictates that no other actions or responses be implemented at a source and that the remaining contaminated sources remain at the site with no plans for future control or removal. The no-action alternative assumes a minimal level of effort to maintain previous remedial actions and to keep them in a safe condition.

The components of Alternative 1A include:

1. Annual exterior inspection of the Gregory Incline and National Tunnel Pipelines.
2. Cleaning of the Gregory Incline and National Tunnel Pipelines every five years.
3. Annual inspection and routine maintenance of existing waste rock pile caps and stabilized channels.

No surface water or ground water monitoring would be performed under this alternative.

Significant issues associated with the no action alternative include the following:

1. Direct adit discharges from the Gregory Incline and National Tunnel to the North Fork will continue unchecked and untreated.
2. Discharge from the Quartz Hill Tunnel will continue unchecked and untreated to Nevada Gulch and, ultimately, the North Fork.
3. Sediment loads derived from erosion of mine waste piles in Gregory and Russell Gulch will continue unchecked to these gulches and, ultimately, the North Fork.

4. Sediment loads derived from erosion of mine wastes adjacent to the North Fork will continue unchecked.
5. Non-point source ground water loading to the North Fork through Black Hawk will continue unabated.

9.2 ALTERNATIVE 1B: INSTITUTIONAL CONTROLS

Alternative 1B provides an administrative layer of protection to human health above that offered by the no action alternative. However, because no additional clean-up would be performed under this alternative, it offers the same, unchanged, protection to the environment offered by the no action alternative. Alternative 1B is designed to limit and/or control access to contaminated media.

The major components of Alternative 1B, institutional controls, are:

1. Use of Unilateral Administrative Orders (UAOs) and Administrative Orders on Consents (AOCs) to compel landowners to adhere to soil clean-up standards when performing construction activities in the North Fork basin.
2. Environmental Covenants would be developed to enforce future land use restrictions for properties where, based on residual contaminants that remain, unrestricted future use is not appropriate, or where the integrity of an engineered structure must be maintained to ensure a protective remedy. Annual inspection (exterior) of the Gregory Incline and National Tunnel pipelines.
3. Cleaning of the Gregory Incline and National Tunnel pipelines every five years
4. Annual inspection and routine maintenance of existing waste rock pile caps and stabilized channels.
5. High- and low-flow sampling of the North Fork and main stem of Clear Creek (up and downstream of the North Fork) every other year.

The significant issues associated with Alternative 1B are the same as those associated with the no-action alternative. The net result of implementing Alternative 1B would be that the impacts of historical mine wastes on the North Fork and main stem of Clear Creek would remain largely unchanged. However, there would be some benefit over Alternative 1A, the no-action alternative, in that the use of UAOs, AOCs, and environmental covenants would restrict human access to known waste sources and provide for long-term maintenance of privately performed clean-ups.

9.3 SEDIMENT CONTROL ONLY ALTERNATIVES

9.3.1 Alternative 2A: Tier 1 sediment reduction (sediment controls in Russell and Gregory Gulches)

Alternative 2 A focuses on decreasing the input of contaminated sediments from mine waste piles located in Russell and Gregory Gulch basins to North Clear Creek. This sediment reduction would be achieved by the use of stream channel stabilization, sediment dam construction, and capping/removal of high and medium priority mine waste piles.

The RI Report (RMC 2002b) ranked drainages containing significant volumes of mine wastes in the North Fork sub-basin based on the potential of the mine wastes to: 1) leach metals, and/or 2) deliver significant volumes of sediments to streams via erosion. Drainages were ranked as having a *High, Moderately High*, *Moderate*, or *Low* potential (Figure 9.1). The results of the ranking process are summarized in Table 9.2.

Subsequent to publication of the OU4 RI, Wildeman et al. (2003) screened select mine waste piles within the North Fork basin and developed a priority system for pile remediation. The waste piles evaluated in Wildeman et al. (2003) received a numerical score of 1 (low) to 5 (high) in each of the categories below. Average physical and chemical scores (ranks) were calculated based on these four scores. The combined physical and chemical scores were then employed to prioritize the clean-up of the piles.

Chemical Rating System Categories	**Physical Rating System Categories**
Acidity	Erosion
pH	Distance to Channel
Toxicity (aquatic)	Vegetation on Pile
Conductivity	Kill Zone Below Pile

Alternative 2A focuses on reducing the erosion and transport of mine wastes from the high and medium priority mine waste sources in Gregory and Russell Gulches. This will be achieved by either: 1) removal of the piles; or 2) excavation of mine wastes from areas adjacent to and in stream channels with consolidation of the materials on the main pile and capping (pull back and cap), construction of run-on ditches around the capped waste piles, and channel stabilization. Capping options include either a vegetated soil cap or rock overlying filter fabric. The mine waste piles included in the Tier 1 sediment reduction alternative are shown in Figure 9.2 and the recommendations for remediation of these piles are the following:

Pile	**Proposed Remedial Action**
Old Jordan	Remove
Niagara	Remove
Mattie May	Cap with Rock
Baltimore	Cap with Rock
Centennial	Remove
Pittsburgh	Cap with Rock
Upper Nevada Gulch Piles	Soil Cap and Revegetate (northern aspect)
Upper Nevada Gulch Piles	Cap with Rock (southern aspect)
Gregory Gulch No. 3	Remove
Argo	Cap with Rock
Druid	Consolidate and Stabilize
Iroquois	Cap with Rock
Anchor	Soil Cap and Revegetate
Hazeltine	Soil Cap and Revegetate

The "Upper Nevada Gulch Piles" include mine wastes associated with the American Flag and University-Kansas shafts and other, adjacent piles. These mine waste piles are considered to be the priority mine waste piles of OU4 which should be remediated as a part of all alternatives that include Tier 1 sediment reductions.

The major components of Alternative 2A, Tier 1 sediment reduction, are:

1. Annual inspection (exterior) of the Gregory Incline and National Tunnel pipelines.
2. Cleaning of the Gregory Incline and National Tunnel pipelines every five years
3. Annual inspection and routine maintenance of existing waste rock pile caps and stabilized channels.
4. High- and low-flow sampling of the North Fork and main stem of Clear Creek (up and downstream of the North Fork) every other year.
5. Construction of sediment dams in Russell Gulch above the confluence with Willis Gulch, in Nevada Gulch below Nevadaville, in Willis Gulch below the confluence with South Willis Gulch, and in Russell Gulch below the confluence with Lake Gulch. Potential dam locations are shown on Figure 9.2.
6. Capping or removal of the waste piles mentioned above.
7. Construction of run-on ditches upslope of the Mattie May, Baltimore, Hazeltine, Pittsburgh, Upper Nevada Gulch Piles, Iroquois, Druid, Anchor, and Argo.

The general locations of the Alternative 2A tributary components are shown in Figure 9.2, 9.5 and 9.6 Detailed information regarding the construction of sediment dams, waste pile caps, and run-on ditches can be found in the OU4 Feasibility Study (FS) (RMC 2004) located in the Administrative Record.

Significant issues associated with Alternative 2A include the following:

1. Direct adit discharges from the Gregory Incline and National Tunnel to the North Fork will continue unchecked and untreated.
2. Discharge from the Quartz Hill Tunnel will continue unchecked and untreated to Nevada Gulch and, ultimately, the North Fork.
3. Sediment loads derived from the erosion of mine wastes adjacent to the North Fork will continue unchecked.
4. Non-point source ground water loading to the North Fork through Black Hawk will continue unabated.

9.3.2 Alternative 2B: Tier 2 sediment reduction (sediment controls on the tributaries and main stem of North Fork)

The Tier 2 sediment reduction builds upon the work proposed in Alternative 2A. Tier 2 includes all the components contained in Tier 1, plus similar work on the main stem of the North Fork. This sediment work is paired with improvements of the channel, banks, and general riparian area of the main stem of the North Fork.

The sediment reduction components performed in the tributaries of the North Fork under Alternative 2B are the same as those in Alternative 2A. The sediment reduction and channel/bank/riparian area reconstruction components on the main stem of the North Fork under Alternative 2B include:

1. Remove mine waste from the channel and riparian zone (within 100-year floodplain).
2. Reconstruct disturbed portions of the channel to proper channel section, riffle-pool complex and planform.

3. Reconstruct the channel with appropriate sinuosity.
4. Stabilize channel using deformable banks, stone toe protection with soil lifts, root wads or j-hooks.
5. Revegetate riparian zone.
6. In areas where constricted floodplain limits room to increase channel sinuosity and to develop proper planform, employ grade control structures (e.g., v-weirs) for grade control.

The general locations of the Alternative 2B tributary components are shown in Figure 9.2., 9.5 and 9.6. General areas for application of the components along the main stem of the North Fork are illustrated on Figure 9.3. Detailed information on the above-mentioned channel reconstruction techniques is available in the OU4 FS.

9.4 ALTERNATIVES COMBINING WATER COLLECTION AND TREATMENT WITH SEDIMENT CONTROLS

9.4.1 Alternative 3A: Water Treatment at Existing Argo Water Treatment Plant Coupled with Tier 1 Sediment Reduction

Alternative 3 A combines the treatment of mine drainage from the National Tunnel and Gregory Incline, and the contaminated alluvial ground water in Gregory Gulch (which contains a component of the Quartz Hill Tunnel discharge) with the Tier 1 sediment reduction proposed under Alternative 2A. Water treatment would be performed at the existing Argo Water Treatment Plant located in Idaho Springs. Treated water would be discharged to Clear Creek.

The water collection, conveyance, and treatment components of Alternative 3 A include:

1. A pump station and pipeline conveying the National Tunnel discharge to the Gregory Incline.
2. A pipeline and series of pump stations to convey the combined Gregory Incline and National Tunnel water to the Prize Shaft.
3. An interceptor trench at the base of the Gregory Gulch alluvium near the upstream entrance of the Gregory Gulch box culvert through Black Hawk.
4. A sump and pump station on the up gradient side of the interceptor trench, and a pipeline connecting to the combined Gregory Incline/National Tunnel pipeline (No. 2 above).
5. Improvements/upgrades, as needed, to the Argo Water Treatment Plant to process the additional inflow and/or different influent chemistry.

The Tier 1 sediment reduction components of Alternative 3 A are the same as those in Alternative 2A. The locations of the Alternative 3A components are shown on Figures 9.2, 9.4, 9.5, and 9.6.

Significant issues associated with Alternative 3A include the following:

1. Sediment loads derived from erosion of mine wastes adjacent to the North Fork will continue unchecked.
2. Non-point source ground water loading to the North Fork through Black Hawk will continue unabated; ground water in Gregory Gulch will be collected and treated.
3. The ability of the Prize Shaft and Argo Tunnel to efficiently convey water to the treatment plant needs to be verified.

9.4.2 Alternative 3B: Water Treatment at New Water Treatment Plant in the North Fork Basin Coupled with Tier 1 Sediment Reduction

As does Alternative 3 A, this alternative combines the active treatment of mine drainage and contaminated ground water with Tier 1 sediment reduction. Unlike Alternative 3A, this alternative would discharge treated effluent back to the North Fork. Consequently, Alternative 3B would additionally benefit the North Fork by: 1) increased dilution, and 2) the addition of hardness and alkalinity, with a concurrent small reduction in metal aquatic toxicity. These benefits would be most significant during low-flow conditions.

The water collection, conveyance, and treatment components of Alternative 3B include:

1. A pump station and pipeline conveying the National Tunnel discharge to the Gregory Incline.
2. An interceptor trench at the base of the Gregory Gulch alluvium near the upstream entrance of the Gregory Gulch box culvert through Black Hawk.
3. Sumps, pump stations, and pipelines to convey the Gregory Gulch alluvial ground water, Gregory Incline discharge, and the National Tunnel discharge to a new water treatment plant.
4. A new lime-based water treatment plant with a design capacity of 500 gpm located in the general Black Hawk/Central City area.

The Tier 1 sediment reduction components of Alternative 3B are the same as those in Alternative 2A. The locations of the Alternative 3B components are shown on Figures 9.2, 9.5,9.6, and 9.7.

Significant issues associated with Alternative 3A include the following:

1. Sediment loads derived from erosion of mine wastes adjacent to the North Fork will continue unchecked.
2. Non-point source ground water loading to the North Fork through Black Hawk will continue unabated; ground water in Gregory Gulch will be collected and treated.
3. Acquisition of land to construct the new water treatment plant may be expensive/difficult.

9.4.3 Alternative 3C: Water Treatment at Existing Argo Water Treatment Plant with Tier 2 Sediment Reduction

Like Alternative 3A, this alternative utilizes the existing Argo Water Treatment Plant to treat the mine drainage from the National Tunnel and Gregory Incline, and the contaminated alluvial ground water in Gregory Gulch, which contains a component of the Quartz Hill Tunnel discharge. Unlike Alternative 3A, which includes only sediment reduction on tributaries (i.e., Tier 1), Alternative 3C will pair the active treatment of major point and non-point source discharges with Tier 2 sediment reduction (Alternative 2B). The Tier 2 sediment reduction includes all the work proposed on the tributaries under Tier 1 plus work on the main stem of the North Fork.

The water collection, conveyance, and active treatment components of Alternative 3C are the same as those for Alternative 3A. Specifically, this includes:

1. A pump station and pipeline conveying the National Tunnel discharge to the Gregory Incline.
2. A pipeline and series of pump stations to convey the combined Gregory Incline and National Tunnel water to the Prize Shaft.
3. An interceptor trench at the base of the Gregory Gulch alluvium near the upstream entrance of the Gregory Gulch box culvert through Black Hawk.

4. A sump and pump station on the up gradient side of the interceptor trench, and a pipeline connecting to the combined Gregory Incline/National Tunnel pipeline (No. 2 above).
5. Improvements/upgrades, as needed, to the Argo Water Treatment Plant to process the additional inflow and/or different influent chemistry.

The Tier 2 sediment reduction components of Alternative 3C are the same as those in Alternative 2B

The sediment reduction and channel/bank/riparian area reconstruction components on the main stem of the North Fork under Alternative 3C include:

1. Remove mine waste from the channel and riparian zone (within 100-year floodplain).
2. Reconstruct disturbed portions of the channel to proper channel planform.
3. Stabilize channel using deformable banks, stone toe protection with soil lifts, root wads or j-hooks.
4. Revegetate riparian zone.
5. In areas where constructed floodplain limits room to develop proper planform, employ grade control structures (e.g., v-weirs) for grade control.

The locations of the Alternative 3C components are shown on Figures 9.2, 9.3, 9.4, 9.5, and 9.6.

Significant issues associated with Alternative 3C include the following:
1. Non-point source ground water loading to the North Fork through Black Hawk will continue unabated; ground water in Gregory Gulch will be collected and treated.
2. The ability of the Prize Shaft and Argo Tunnel to efficiently convey water to the treatment plant needs to be verified.

9.4.4 Alternative 4A: Water Treatment using Passive Treatment System Coupled with Tier 1 Sediment Reduction

Alternative 4 A combines the treatment of mine drainage from the National Tunnel and Gregory Incline, and the contaminated alluvial ground water in Gregory Gulch (which contains a component of the Quartz Hill Tunnel discharge) with the Tier 1 sediment reduction proposed under Alternative 2A. Water treatment would be performed at a passive treatment system located in the North Fork basin along highway 119. This passive water treatments system would employ several sulfate reducing bioreactors (SRBRs), which would precipitate metals out of solution as metal sulfides, thereby reducing metal concentrations in the surface water. The passive treatment system would also employ a free water surface (FWS) cell which would reoxygenate the surface water once it has passed through the SRBR cells. The area needed to construct the passive system would be 5-10 acres. The treated water would be discharged into the North Fork.

The water collection, conveyance, and treatment components of Alternative 4 A include:

1. An interceptor trench at the base of the Gregory Gulch alluvium near the upstream entrance of the Gregory Gulch box culvert through Black Hawk.
2. A sump and pump station on the up gradient side of the Gregory Gulch interceptor trench, and a pipeline connecting to the Gregory Incline/National Tunnel pipeline.
3. A gravity pipeline configured as full-pipe flow conveying the Gregory Incline discharge down the North Fork to the National Tunnel outfall, where the discharges would be combined and

continue downstream in a gravity pipeline (full pipe flow) to the passive treatment system location.
4. SRBR cells, plumbed in parallel. The surface water from the SRBR cells would flow to a FWS cell for polishing prior to discharge to the North Fork.

The Tier 1 sediment reduction components of Alternative 4A are the same as those in Alternative 2 A. The locations of the Alternative 4A components are shown on Figures 9.2, 9.5, and 9.6.

Significant issues associated with Alternative 4A include the following:

1. Sediment loads derived from erosion of mine wastes adjacent to the North Fork will continue unchecked.
2. Non-point source ground water loading to the North Fork through Black Hawk will continue, with the exception of that associated with the Gregory Gulch alluvium.
3. Largest property acquisition of all alternatives considered.
4. Potential decreased performance of the Sulfate Reducing Bioreactor (SRBR) and free water surface (FWS) polishing cell during cold conditions.
5. Potential odors.
6. Potential inability of SRBRs to meet State/Federal discharge requirements.

9.4.5 Alternative 4B: Combined Active and Passive Water Treatment with Tier 2 Sediment Control

Alternative 4B blends active and passive treatment of acid mine drainage discharges with the aggressive sediment control proposed under the Tier 2 sediment reduction work (Alternative 2B). Alternative 4B utilizes the Bates-Hunter Mine water treatment plant, an existing privately owned active water treatment plant in Central City, to treat the discharge from the Gregory Incline and the Gregory Gulch alluvial ground water. Passive treatment, in the form of SRBR cells and a FWS cell, would be used to treat the National Tunnel discharge. The treated water, both from the active and passive treatment systems, would be discharged into the North Fork.

The water collection, conveyance, and treatment components of Alterative 4B include:

1. An interceptor trench at the base of the Gregory Gulch alluvium near the upstream entrance of the Gregory Gulch box culvert through Black Hawk.
2. A sump and pump station on the up gradient side of the Gregory Gulch interceptor trench, and a pipeline connecting to the Bates Hunter Mine Water Treatment Plant.
3. A pump station and pipeline connecting the Gregory Incline discharge to the Bates Hunter Mine Water Treatment Plant.
4. A gravity pipeline configured as full-pipe flow conveying the National Tunnel discharge downstream to the passive treatment system location.
5. SRBR cells. The effluent from the SRBR cells would flow to a FWS cell for polishing prior to discharge to the North Fork.

The Tier 2 sediment reduction components of Alternative 4B are the same as those in Alternative 2B.

The sediment reduction and channel/bank/riparian area reconstruction components on the main stem of the North Fork under Alternative 4B include:

1. Remove mine waste from the channel and riparian zone (within 100-year floodplain).
2. Reconstruct disturbed portions of the channel to proper planform.
3. Stabilize channel using deformable banks, stone toe protection with soil lifts, root wads or j-hooks.
4. Revegetate riparian zone.
5. In areas where constructed floodplain limits room to increased develop proper planform, employ grade control structures (e.g., v-weirs) for grade control.

The locations of the Alternative 4B components are shown on Figures 9.2, 9.3, 9.5 and 9.6.

Significant issues associated with Alternative 4B include the following:

1. Non-point source ground water loading along North Fork of Clear Creek will continue unabated; ground water in Gregory Gulch will be collected and treated.
2. For the National Tunnel SRBR passive treatment system, potential decreased performance during cold conditions, potential odors, and potential inability to meet State/Federal discharge requirements.

SECTION 10

SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

The NCP requires that each remedial alternative be profiled against nine evaluation criteria. A description of the nine criteria is provided below. A summary of the comparative analysis is presented in Table 10.1. This comparative analysis has been changed from the analysis in the Feasibility Study. The information in Table 10.1 is considered final.

1. **Overall Protection of Human Health and the Environment** addresses whether a remedy provides adequate protection and describes how risks posed through each pathway are eliminated or reduced, or controlled through treatment, engineering controls, or institutional controls.

2. **Compliance with Applicable or Relevant and Appropriate Requirements** addresses whether a remedy will meet all federal and state environmental laws or regulations and/or provide grounds for a waiver.

3. **Long-term Effectiveness and Permanence** refers to the ability of a remedy to provide reliable protection of human health and the environment over time.

4. **Reduction of Toxicity, Mobility, or Volume Through Treatment** refers to the preference for a remedy that reduces health hazards, the movement of contaminants, or the quantity of contaminants at the Site.

5. **Short-term Effectiveness** addresses the period of time needed to complete the remedy, and any adverse effects to human health and the environment that may be caused during the construction and implementation of the remedy.

6. **Implementability** refers to the technical and administrative feasibility of a remedy. This includes the availability of materials and services needed to carry out a remedy. It also includes coordination of Federal, State, and local governments to work together to clean up the Site.

7. **Cost** evaluates the estimated capital, operation, and maintenance costs of each alternative in comparison to other equally protective alternatives.

8. **State Acceptance** indicates whether the State of Colorado agrees with, opposes, or has no comment on the selected alternative.

9. **Community Acceptance** includes determining which components of the alternatives interested persons in the community support, have reservations about, or oppose.

The first two criteria, overall protection of human health and the environment, and compliance with legally applicable and relevant and appropriate requirements, are considered threshold criteria. This means that for a cleanup alternative to be considered for implementation it must, at a minimum, satisfy these two criteria or provide justification for invoking a waiver of the requirement(s).

Evaluation criteria three through seven are known as primary balancing criteria, and are used to identify the alternative(s) which provide the best combination of individual criteria. Evaluation criteria eight and nine are known as modifying criteria and are used in conjunction with the primary balancing criteria to identify the preferred cleanup alternative. The modifying criteria are generally determined after public comment, and may be used to modify the preferred cleanup alternative.

10.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls.

The no action alternative (Alternative 1A) and the institutional controls alternative (Alternative 1B) are not protective of human health and the environment.

Alternatives 2A and 2B would reduce the mobilization and transport of sediment from mine waste piles within the North Fork basin to the main stem of the North Fork, however, neither alternative addresses adit discharges or non-point source ground water contamination. Both alternatives would result in a measurable improvement in water quality and aquatic habitat (Alternative 2B greater than 2A) by reducing the leaching of metals from sediments and waste piles that would otherwise further contaminate the surface water. Both alternatives would protect human health and the environment from risks associated with sediment and waste piles. However, these alternatives would need to be paired with water treatment technologies in order to protect human health and the environment from risks associated with surface water and ground water.

Alternatives 3 A, 3B, 3C, 4A, and 4B address both treatment of point and non-point source discharges as well as sediment reduction, thereby reducing the risk associated with exposure to surface water, ground water, and waste piles. Alternatives 3A and 3B couple active treatment of point and non-point source discharges (i.e., National Tunnel, Gregory Incline, Gregory Gulch alluvial ground water) with Tier 1 sediment reduction actions (waste piles on tributary drainages). The difference between these two alternatives is that 3A utilizes the existing Argo facility for water treatment and 3B considers the construction of a new water treatment plant in the North Fork basin. Alternative 3C, like 3 A, utilizes the Argo facility to treat the National Tunnel and Gregory Incline discharges along with Gregory Gulch alluvial ground water. However, Alternative 3C couples the active treatment of these point and non-point source discharges with the Tier 2 sediment reduction/passive water treatment actions (waste piles on main stem of North Fork and tributaries). Each of the 3-series alternatives offers an increased level of protection to human health and the environment over Alternatives 2 A and 2B. Alternative 3B, because it would discharge treated water back to the North Fork (increasing dilution and hardness) may be slightly more protective than Alternative 3 A. Of the 3-series Alternatives, Alternative 3C provides the greatest protection to aquatic life and habitat in the North Fork (segment 13b) under all flow conditions. Alternative3C couples water treatment of the main acid mine discharges with the more extensive Tier 2 sediment improvements, whereas Alternative 3A and 3B are coupled with the less protective Tier 1 sediment improvements.

Alternative 4A, which incorporates passive treatment of the main acid mine discharges, will be less protective of human health and the environment than Alternative 3 A and 3B because the effectiveness of passive treatment is less than that of active treatment technologies. Alternative 4B, which uses a combination of active treatment for the Gregory Incline and Gregory Gulch and passive treatment for the National Tunnel, may be slightly less protective than Alternative 3C because 4B uses passive treatment for the National Tunnel. Alternatives 4B and 3C are both more protective than the rest of the remedies because they couple treatment of the mine drainages with Tier 2 sediment improvements. The Bates Hunter Mine treatment plant (Alternative 4B) may not have sufficient capacity during spring runoff to treat all of the Gregory Incline discharge and Gregory Gulch alluvial ground water, as well as the water from the Bates Hunter Mine, if the discharges increase flow substantially. However, remediation goals are still anticipated to be met by Alternative 4B, even if such increase occurs, because of the lower in-stream concentrations that also occur during spring runoff. Alternative 4B may be slightly more protective than Alternative 3C during low-flow because Alternative 4B discharges treated water to the North Fork of Clear Creek, adding hardness and dilution water to stream, whereas for Alternative 3C the treated mine drainages would be discharged for the Argo Tunnel plant to the main steam of Clear Creek,

The predicted ability of the nine alternatives to meet the OU4 preliminary remediation goals for surface water is summarized on the tables below. Separate tables are provided for the North Fork Segment 13b and Clear Creek Segment 11 below the confluence with the North Fork. Information on low- and high-flow conditions is presented on each table. Additionally, the Clear Creek tables provides Remedial Goal achievement estimates at both the confluence with the North Fork of Clear Creek and downstream at Golden.

Ability to Attain Surface Water RGs in the North Fork of Clear Creek Segment 13b
(Y = RG met; N = RG not met)

Metal	Flow Regime	Alternative								
		1A	1B	2A	2B	3A	3B	3C	4A	4B
Cadmium	Low Flow (Sep 1-Apr 30)	N	N	N	N	Y	Y	Y	Y	Y
Copper		N	N	Y	Y	Y	Y	Y	Y	Y
Manganese		N	N	N	N	Y	Y	Y	Y	Y
Zinc		N	N	N	N	N	N	Y	N	Y
Cadmium	High Flow (May 1-Aug 31)	N	N	N	N	Y	Y	Y	Y	Y
Copper		N	N	N	N	N	N	N	N	N
Manganese		N	N	Y	Y	Y	Y	Y	Y	Y
Zinc		N	N	N	N	Y	Y	Y	Y	Y

Ability to Attain Surface Water RGs in Clear Creek Segment 11 (below North Fork)
(Y = RG met; N = RG not met)

Metal	Flow Regime	Alternative								
		1A	1B	2A	2B	3A	3B	3C	4A	4B
Cadmium	Low Flow (Sep 1-Apr 30)	Y*	Y*	Y*	Y*	Y*	Y*	Y*	Y*	Y*
Copper		N	N	Y	Y	Y	Y	Y	Y	Y
Iron		Y*	Y*	Y*	Y*	Y*	Y*	Y*	Y*	Y*
Manganese		N* Y*	N* Y*	N* Y*	N* Y*	N* Y*	N* Y*	N* Y*	N* Y*	N* Y*
Zinc		N* N	N* N	N* N	N* N	N* Y	N* Y	N* Y	N* Y	N* Y
Cadmium	High Flow (May 1-Aug 31)	Y*	Y*	Y*	Y*	Y*	Y*	Y*	Y*	Y*
Copper		N*	N*	N*	N*	N*	N*	N*	N*	N*
Iron		N*	N*	N*	N*	N*	N*	N*	N*	N*
Manganese		Y*	Y*	Y*	Y*	Y*	Y*	Y*	Y*	Y*
Zinc		N* Y*	N* Y*	N* Y*	N* Y*	N* Y*	N* Y*	N* Y*	N* Y*	N* Y*

Notes: Y* - The RG is met under current conditions.
N* - The load removal required to meet the RG exceeds the load currently conveyed by the North Fork of Clear Creek.
Where "Y" and/or "N" both provided, the first value refers to Clear Creek at confluence with the North Fork and the second value refers to Clear Creek at Golden. If only one value present, it refers to the entire reach.

In summary, Alternatives 3C and 4B meet all surface water Remediation Goals in North Clear Creek Segment 13b except for copper under high-flow conditions. To meet the copper PRO, additional actions involving the collection and treatment of the Quartz Hill Tunnel discharge may be required. While all alternatives 2 A and higher would lessen the impact of the North Fork on Clear Creek Segment 11, none would meet all surface water PRGs under low- and high-flow conditions. Under high-flow conditions, the load reductions required to meet the PRGs for copper and zinc (at the confluence) exceed the loads currently carried by the North Fork; the same situation exists for manganese and zinc (both at the confluence) during low-flow conditions. Additional source controls, such as the sediment control measures and ground water treatment currently planned for Virginia Canyon, would be required to meet all the PRGs in Clear Creek Segment 11 downstream of the confluence with the North Fork.

The alternatives are listed in descending order of their protectiveness of human health and the environment as follows:

3C> 4B> 3B ~ 3A> 4A >> 2B> 2A >> 1B> 1A

10.2 COMPLIANCE WITH APPLICABLE, RELEVANT, AND APPROPRIATE REQUIREMENTS (ARARs)

Section 121(d) of CERCLA and NCP 300.430(f)(l)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations, which are collectively referred to as ARARs, unless such ARARs are waived under CERCLA 121(d)(4).

The chemical-specific ARARs for OU4 can be found in Table 10.2, location-specific ARARs in Table 10.3 and action-specific ARARs in Table 10.4. These ARARs tables have been updated and changed since the completion of the Feasibility Study. The ARARs tables included in this document are final, therefore the compliance of all remedial actions with ARARs should be assessed using the ARARs located in Tables 10.2, 10.3, and 10.4. The surface water ARARs are indicated in the table below:

Applicable or Relevant and Appropriate Requirements
For Surface Water (µg/L)

	North Fork (segment 13b)	Main stem of Clear Creek (segment 11)
Zinc	740	300
Cadmium (high flow/low flow)	1.9/3.5	1.4/2.9
Copper	64	17
Manganese (high flow/low flow)	1,431/2,021	600

For the main stem of Clear Creek downstream of the confluence with the North Fork of Clear Creek none of the alternatives would meet the manganese and zinc ARARs at the confluence during low-flow conditions unless upstream improvements in the main stem of Clear Creek are sufficient. However with other anticipated upstream improvements such as treatment of Virginia Canyon ground and surface waters, it is anticipated that the main stem ARARs would be achieved by the 3-series and 4-series Alternatives. Future monitoring will indicate whether additional improvements will be needed to achieve ARARs on the main stem of Clear Creek.

For the North Fork of Clear Creek, Alternatives 3C and 4B are the only alternatives that are anticipated to meet the zinc ARAR of 740 µg/L during low-flow. Hence Alternatives 3C and 4B are the only Alternatives that are anticipated to meet all ARARs.

For a comparison between the surface water ARAR values and the Remediation Goal values, the surface water Remediation Goals are given in the table below:

Metal	Remediation Goals (µg/L)		
	Flow Regime	**North Fork (Segment 13b)**	**Clear Creek Below North Clear Creek (Segment 11 - lower portion)**
Zinc (dissolved)	High-Flow	381	200
	Low-Flow	675	300
Copper (dissolved)	High-Flow	7.4	5.2
	Low-Flow	15.1	9.2
Cadmium (dissolved)	High-Flow	1.9	1.4
	Low-Flow	3.5	2.3
Manganese (dissolved)	High-Flow	1,531	600
	Low-Flow	2,021	600

As discussed in section 10.1, the only alternatives to meet all RGs in the North Fork Segment 13b during low-flow were Alternatives 3C and 4B. During high-flow conditions, none of the alternatives are projected to meet the copper RGs for the North Fork segment 13b. However, the ARAR for copper is 64 µg/L at both high and low flow, which is less stringent than the RG of 7.4 µg/L. The water treatment alternatives, Alternatives 3A, 3B, 3C, 4A, and 4B, would meet the copper ARAR during high and low flow on the North Fork. The copper ARAR is not protective of the Remedial Action Objective of protecting the survival of brown trout. Therefore, it is necessary to remove more copper than is needed to meet the ARAR so that this Remedial Action Objective may be attained.

In Clear Creek Segment 11 below the confluence with the North Fork, none of the alternatives will meet all Remediation Goals under both low-flow and high-flow conditions due to the load contributions from other upstream sources in the Clear Creek basin. However, as noted above, with the other anticipated upstream improvements, it is anticipated that the main stem of Clear Creek ARARS will be met. The five-year review will be used to determine if the chosen remedy is indeed protective of human health and the environment, achieves remedial action objectives, complies with ARARs, if additional remedial action is needed, or if an ARAR waiver would ultimately be appropriate.

Alternatives 1 A, IB, 2A, and 2B will not, by themselves, comply with ARARs during either high-flow or low-flow. These alternatives do not consider treatment of the National Tunnel discharge, Gregory Incline discharge, or Gregory Gulch ground water (that includes a component of Quartz Hill Tunnel discharge). Consequently, ARARs specific to stream standards and discharge permits might have to be waived if either of these alternatives were implemented without concurrent treatment of surface and/or ground water.

The alternatives are listed below in descending order with respect to their compliance with ARARs. Alternatives 3C and 4B are the only alternatives that are anticipated to comply with all ARARs:

3C ~ 4B > 3B ~ 3A > 4A >> 2B > 2A > 1B > 1A

10.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

Long-term effectiveness is evaluated in terms of residual risk remaining at the Study Area after the remedial action has been implemented. Alternatives are also evaluated as to the effectiveness of the remedy over the project lifetime. Alternatives more effective in the long-term are more permanent.

Alternatives with the ability to reduce the loading from source areas active under all flow regimes to the North Fork and, subsequently, the main stem of Clear Creek provide the most assurance of long-term effectiveness and permanence. Alternatives that would not address releases of untreated water and/or influx of sediments from disturbed drainages would have a low long-term effectiveness and permanence.

Alternatives 1A (no action) and 1B (institutional controls) do not consider any actions that would reduce the input of contaminants to the surface water system. Consequently, there would be no reduction in contaminant concentrations in surface water as a direct result of the implementation of either alternative. Therefore, Alternatives 1A and 1B would have no long-term effectiveness and permanence with respect to protecting aquatic life and the environment. With its use of other mechanisms (e.g., the Colorado Environmental Real Covenant Act), Alternative 1B. would offer more long-term effectiveness and permanence than Alternative 1A with respect to human health.

Alternatives 2 A and 2B target reducing the influx of sediment introduced to the North Fork from mine waste piles. Alternative 2A (Tier 1 sediment reduction) targets mine waste in high priority drainages (i.e., Russell and Gregory Gulches); whereas, Alternative 2B (Tier 2 sediment reduction/passive water treatment) targets mine wastes in and adjacent to the North Fork in addition to Tier 1 actions.

Alternatives 2A and 2B target reducing the influx of sediment introduced to the North Fork from mine waste piles. Alternative 2A (Tier 1 sediment reduction) targets mine waste in high priority drainages (i.e., Russell and Gregory Gulches); whereas, Alternative 2B (Tier 2 sediment reduction) targets mine wastes in and adjacent to the North Fork in addition to Tier 1 actions.

Reactive transport modeling results support the conclusion that Remediation Goals would not be met through the implementation of Alternative 2A or 2B (Medine 2003). Even under Medine's (2003) most aggressive sediment removal scenario modeled (i.e., 67 percent reduction from Gregory and Russell Gulches), the modeling results suggest that surface water PRG for zinc would not be met in the North Fork of Clear Creek.

The alternatives that consider both sediment control and water treatment provide for the highest level of long-term effectiveness and permanence. Alternatives 3 A, 3B, and 4A target both the sediment loads addressed under Tier 1 sediment control and specific point source discharges to the North Fork, while Alternatives 3C and 4B combine water treatment with Tier 2 sediment control. Alternative 3B may be slightly more effective than Alternative 3A in the North Clear Creek basin. Both alternatives should be equally effective in Clear Creek below the confluence with the North Fork. The permanence of Alternatives 3 A and 3C is uncertain due to the unknown condition of the Prize workings and the Argo Tunnel. Both alternatives rely on these historical mine workings to transfer water from the North Fork basin to the Clear Creek basin for treatment. The integrity of the Prize-Argo system would have to be tested during the remedial design phase.

Alternative 4A utilizes passive treatment to treat specific point source discharges to the North Fork. The long-term effectiveness and permanence of passive treatment systems may be compromised by repeated or large flooding events, which have the potential to damage the sulfate reducing bioreactor cells and free water surface cells. The long-term effectiveness of passive treatment systems on a scale such as would be implemented under Alternative 4A is not well documented. Pilot-scale studies would potentially need to be implemented to better determine the long-term effectiveness of passive treatment as the sole source of water treatment along the North Fork.

Alternative 4B relies on passive treatment of the National Tunnel discharge as well as the leasing of the Bates Hunter water treatment facility from a private party for the treatment of the Gregory Incline discharge and Gregory Gulch ground water. The same issues regarding passive treatment discussed above apply to Alternative 4B. However, since the Gregory Incline discharge and Gregory Gulch ground water will be treated at a water treatment facility, the long-term effectiveness and permanence of this alternative will be greater. This is due to the increased reliability of a water treatment plant to effectively treat the water year round. Because of the reliance on a private-public cooperative agreement, the long-term effectiveness and permanence of Alternative 4B is considered to be less than that of those alternatives, such as Alternative 3B, in which the State would own the plant.

The alternatives are ranking in decreasing order of their long-term effectiveness and permanence below:

$$3B > 3C > 3A > 4B > 4A >> 2B > 2A >> 1B > 1A$$

10.4 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

This criterion addresses the application of technologies that permanently or significantly reduce toxicity, mobility, or volume of contaminants. In the case of OU4, the contaminants include historical mine wastes and discharge from tunnels. While controls can be implemented to restrict the mobility of contaminants from mine waste piles, the reduction in toxicity and volume of the largest source of acid mine drainage at the site (i.e., tunnel discharges) requires treatment.

Alternatives 1A and 1B involve no cleanup or treatment of contaminants. Alternative 1B would attempt to restrict exposure to contaminants with institutional controls, but neither alternative would reduce, in themselves, the toxicity, mobility or volume of contaminants.

The actions considered under Alternatives 2A and 2B target the erosion and transport of contaminants and sediment from historical mine waste piles through removal, capping, water control, and collection of sediment. The actions proposed under Tier 1 sediment reduction would be included in Alternatives 3A, 3B, and 4A, while Tier 2 sediment reduction would be included in Alternatives 3C and 4B. Although the goal of the sediment reductions is to reduce the mobility of sediments, this reduction will come through the application of engineering measures, not through treatment. The sediments retained in the sediment basins under both Alternatives 2A and 2B will need to be periodically removed and will be disposed of at the on-site mine waste repository, consolidated with other wastes, or disposed of off-site. Additionally, select waste piles would be removed under Alternatives 2A and 2B, and disposed at the on-site mine waste repository, consolidated with other wastes, or disposed of off-site. While the removal of these piles would decrease mobility, the toxicity and volume of the wastes would remain the same; the wastes would, however, be relocated to a more stable and secure location.

Alternatives 3A, 3B, 3C, and 4B include conventional water treatment technology. These alternatives can be differentiated by the location of their discharge points. Alternatives 3 A and 3C would discharge treated water to Clear Creek, while Alternatives 3B and 4B would discharge treated water back to the North Fork basin. Because additional contaminant source areas will remain in the North Fork basin, metals will still be present in the North Fork. Alternatives 3B and 4B would discharge treated water back to the North Fork, thereby contributing to the dilution of the metal load to the North Fork.

Although the relative contribution of the water treatment plant effluent to the North Fork flows may only amount to no more than 10 percent under low-flow conditions, the addition of clean effluent may decrease the toxicity of the North Fork water through dilution. Additionally, the use of lime in the treatment process will contribute calcium (hardness) and alkalinity to the effluent, which would further decrease the toxicity of some residual metals present in North Fork water. Because Alternatives 3A and 3C would export the contaminated water from the North Fork basin to the Argo facility and discharge the effluent to Clear Creek, the toxicity of the North Fork water may be slightly lower under Alternative 3B as compared to Alternative 3 A. Both Alternatives 3A and 3B are anticipated to yield similar reductions in the main stem Clear Creek downstream of the North Fork.

Sludge is the product of conventional water treatment processes. Alternatives 3 A, 3B, 3C, and 4B employ active water treatment that will produce sludge. Consequently, the relative volume and characteristics of the sludge generated in Alternatives 3 A, 3B, 3C, and 4B is expected to be similar. Sludge generated by active treatment would be consolidated at an on-site mine waste repository, or disposed of at an offsite facility as the Argo sludge currently is.

Alternative 4A relies entirely on the use of passive treatment technologies to treat the National Tunnel discharge, the Gregory Incline discharge, and the Gregory Gulch alluvial ground water. Alternative 4B would utilize passive treatment technology to treat the National Tunnel discharge only. The effectiveness of the passive treatment systems is less than that of an active water treatment plant. Consequently, the passive treatment systems would not reduce the toxicity or volume to the same degree as the active treatment plants. Alternatives 3C and 4B, which employ Tier 2 sediment improvements, would include passive treatment cells along the North Fork of Clear Creek that would need to be periodically mucked out. The sulfate reducing bioreactors used to treat tunnel discharges and alluvial groundwater in Alternative 4A and 4B would also need to be periodically excavated and replaced. Materials would be disposed at an on-site mine waste repository or at an offsite facility.

In summary, Alternatives 1 A, 1B and 2A would yield no reduction in the toxicity, mobility or volume of contaminants through treatment because treatment is not included in these four alternatives. However, Alternative 2A would achieve some reduction in mobility through engineering measures (i.e., waste pile capping, removal). Alternative 2B would reduce mobility like Alternative 2A, though to a slightly larger degree. Alternatives 3A, 3B, 3C, 4A, and 4B would have a much larger reduction in the toxicity, mobility, and volume of contaminants through the use of active and/or passive water treatment technologies.

The alternatives are ranked in decreasing order with respect to their reduction of toxicity, mobility, or volume through treatment is summarized below:

3C > 3B ~ 3A > 4B > 4A >> 2B > 2A > 1B ~ 1A

10.5 SHORT-TERM EFFECTIVENESS

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community, and the environment during construction and operation of the remedy until cleanup levels are achieved.

Alternatives 1A (no action) and 1B (institutional controls) do not consider any actions that would reduce the input of contaminants to the surface water system. Consequently, there would be no change in contaminant concentrations in surface water as a direct result of the implementation of either alternative. Therefore the short-term effectiveness of these alternatives is low.

Alternatives 2A and 2B target reduction of sediment introduced from mine waste piles present in Russell and Gregory Gulches, and adjacent to the North Fork. Once in the North Fork and main stem of Clear Creek, these sediments contribute to non-point metals loading and have a deleterious impact on aquatic habitat. The capping and removal of mine waste piles will decrease the erosion and transport of sediments from select piles. The construction of sediment settling basins will reduce the volume of sediment transported to the North Fork. The short-term effectiveness of Alternatives 2A and 2B is driven by the hydrologic cycle, resulting in an increase in the short-term effectiveness of these alternatives during dry years, and a decrease during wet years with monsoon-like weather in which flooding could over-top sediment basins and increase the erosion of waste piles.

Alternatives 3A, 3B, 4A, and 4B utilize water treatment technologies which will have an immediate impact on the quality of water in the North Fork and main stem of Clear Creek. Therefore, their short-term effectiveness would be high. Because Alternate 4B utilizes an existing water treatment plant, it could be implemented quicker than other alternatives involving treatment.

The alternatives are ranked in descending order with respect to their short-term effectiveness below:

4B > 3B > 3C> 3A > 4A >> 2B > 2A >> 1B > 1A

10.6 IMPLEMENTABILITY

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability for services and materials, administrative feasibility, and coordination with other government entities are also considered.

Alternatives 1A and 1B, because they do not propose any physical clean-up, present no technical difficulty in their implementation. Alternative 2B will be slightly more difficult to implement than Alternative 2A because it involves more sediment reduction measures than Alternative 2A.

Alternatives 3 A and 3C will face the technical and administrative challenges of constructing pipelines through Black Hawk and Central City and to the Prize Shaft. Alternatives 3A and 3C also face the potential technical challenges of using the Prize Mine workings and the Argo Tunnel to convey water to the Argo water treatment plant. Alternatives 3A and 3C may face challenges in acquiring property to expand the Argo treatment plant. Alternative 3B will also face the technical and administrative challenges of constructing pipelines, but these pipelines will be shorter than those proposed under Alternatives 3A and 3C, and involve only one municipality.

Both alternatives 4A and 4B will face the technical and administrative challenges of constructing pipelines through Black Hawk and along Highway 119 below Black Hawk. Alternative 4A would require larger land acquisition. Alternative 4B would require negotiation of a long-term lease with the owner of the Bates Hunter Mine Water Treatment Plant.

The alternatives are ranked in descending order with respect to their ease of implementation below:

1A > 1B >> 2A > 2B > 3A > 3C ~ 4B > 3B ~ 4A

10.7 COST

Table 10.5 describes the costs for each alternative. The costs are broken down into capital costs; 30 year Operation and Maintenance (O&M) costs, which assumes a discount rate of 7% over 30 years; and the total present value of each alternative which sums the capital costs with the O&M costs.

Of the sediment control alternatives, Alternative 2 A is less expensive (total present value = $6,607,000) than Alternative 2B (total present value = $13,004,000) due to the greater amount of sediment control work involved in Alternative 2B.

Alternative 4 A is the least costly of the alternatives that involve both water treatment and sediment controls (total present value = $10,279,000) due to the respectively low O&M costs (present value of O&M = $2,725,000). Alternative 3B is the most expensive of these alternatives (total present value = $32,181,000) due to the large O&M costs associated with maintaining a new water treatment plant along the North Fork of Clear Creek (present value of O&M costs $14,420,000).

Alternatives 3C and 4B are similar in present value (Alternative 3C = $25,157,000, Alternative 4B = $23,329,000), however Alternative 4B has a lower capital cost (approximately $6,000,000 less than Alternative 3C). Alternative 3A is the second least expensive alternative that requires water treatment and sediment controls (total present value = $19,483,000), but it does not include the added protection of Tier 2 sediment improvements.

10.8 STATE ACCEPTANCE

State acceptance typically assesses the comments of the State on EPA lead projects. As the lead agency, the Colorado Department of Public Health and Environment (CDPHE) has participated fully in the remedy selection process. CDPHE and EPA jointly agree that the selected alternative is the most appropriate remedy for OU4.

10.9 COMMUNITY ACCEPTANCE

This criterion evaluates whether the local community agrees with CDPHE's and EPA's analyses and preferred alternative. Community members, the Upper Clear Creek Watershed Association, the Clear Creek Watershed Foundation, Gilpin County Commissioners, and the cities of Black Hawk and Central City have expressed support for the preferred alternative.

SECTION 11

PRINCIPAL THREAT WASTE

The NCP establishes an expectation that EPA will use treatment to address principal threats posed by a site wherever practical (NCP 300.430(a)(l)(iii)(A)). Identifying principal threat wastes combines concepts of both hazard and risk. A principal threat concept is applied to the characterization of "source material" at a Superfund Site. A source material is material that includes or contains hazardous substances or pollutants or contaminants that act as a reservoir for migration of contamination to ground water, surface water, or air, or acts as a source for direct exposure. EPA has defined principal threat wastes as those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human heath or the environment should exposure occur.

Mine waste is not considered to be principal threat waste.

SECTION 12

THE SELECTED REMEDY

The selected remedy is as follows:

Alternative 4B:

- Treatment of Gregory Incline discharge and Gregory Gulch ground water at the Bates Hunter Mine water treatment plant.

- Treatment of the National Tunnel discharge at a passive treatment system downstream of Black Hawk along Highway 119.

- Sediment control involving waste pile removal/capping and sediment reduction measures in Russell, Gregory, and Nevada Gulches, and along the North Fork of Clear Creek (Tier 2 sediment controls).

The selected remedy is discussed more fully below. The selected remedy meets the requirements of the two mandatory threshold criteria: protection of human health and the environment, and compliance with ARARs. The selected remedy meets these requirements while providing the best balance of benefits and tradeoffs among the five balancing criteria: long-term effectiveness and permanence; short-term effectiveness; implementability; reduction of toxicity, mobility, and volume through treatment; and cost. Input from CDPHE and the local municipalities and the community were critical components that were considered. The selected remedy meets the remedial action objectives presented in Section 8.

12.1 SUMMARY OF THE RATIONALE FOR THE SELECTED REMEDY

As, discussed in Section 7, metals-contaminated surface water and sediments and mine wastes pose ecological and human health risks at the site. A primary goal for cleanup actions taken at OU4 is to reduce ecological risk within the Study Area. The remedial action objectives discussed in Section 8 outline the desired future conditions which would result from accomplishing this goal. To achieve the remedial action objectives, the cleanup actions would need to achieve seasonal water quality concentrations that are capable of supporting a brown trout population along the North Fork. The remedial action objectives would also need to achieve water quality concentrations that would support a viable reproducing brown trout population on the main stem of Clear Creek. These standards are identified as remediation goals.

Alternative 4B, the selected remedy, provides the best balance between reducing risk to human health and aquatic organisms and optimizing the nine evaluation criteria. As noted in Section 10.1, Alternative 4B is one of the only alternatives that are predicted to meet all surface water remediation goals along the North Fork (segment 13b). Alternative 4B best accomplishes the surface water RAOs of minimizing water quality and habitat impacts in order to promote the survival of brown trout in the North Fork, and a viable reproducing brown trout population in the main stem of Clear Creek. The selected remedy is one of the only remedies evaluated that has the potential to improve stream habitat as a byproduct of water treatment through the use of the passive treatment system to treat the National Tunnel discharge. The passive treatment system will, by necessity of the system design, increase the ponding of water and the curvature of the river, which will create a more favorable habitat for fish.

The selected remedy also addresses the main sources of surface water metals contamination, namely tunnel discharges and sediment erosion from mine waste piles. The conceptual site models discussed in Section 5 demonstrate the relative importance of the tunnel discharges in controlling water quality in the North Fork. During most of the year, and especially during low-flow, the discharging tunnels contribute the majority of the metals load to the North Fork. Under low-flow conditions, non-point source loads (such as alluvial ground water inflow from Gregory Gulch) comprise an estimated one-third of the metals load to the North Fork. The combined passive and active water treatment proposed under the selected remedy will target the discharging tunnels and non-point source inflows.

During spring runoff, surface water inflow from Gregory and Russell Gulches are the dominant metals loading sources to the North Fork. The Tier 2 sediment reduction actions that are incorporated into the selected remedy will target the high and medium priority mine waste piles and drainages in Gregory, Nevada, and Russell Gulches, and sediment control and mine waste removal on the main stem of the North Fork. Combining these sediment reduction actions with the treatment of point and non-point source discharges will result in significant year-round water quality improvements in the North Fork and main stem of Clear Creek.

12.2 DETAILED DESCRIPTION OF THE SELECTED REMEDY

12.2.1 Sediment Controls

The selected remedy (Alternative 4B) will incorporate Tier 2 sediment controls into its cleanup plan. Tier 2 sediment controls include the following remedial actions:

1. Removal of the following mine waste piles: Niagara, Centennial, and Gregory Gulch No. 3. Waste materials would be trucked to an on-site repository or a centralized mine pile for capping and disposal, or disposed of at a landfill off-site.
2. Capping or stabilization of the following mine waste piles and adjacent areas: Argo, Pittsburgh, Mattie May, Baltimore, Iroquois, Anchor, Druid, Hazeltine, and Upper Nevada Gulch Piles.
3. Stabilization of stream channels if adjacent to capped waste piles.
4. Construction of run-on ditches upslope of the Mattie May, Baltimore, Hazeltine, Pittsburgh, Upper Nevada Gulch Piles, Iroquois, Druid, Anchor, and Argo.
5. Construction of sediment dams in Russell Gulch above the confluence with Willis Gulch, in Willis Gulch above the confluence with Russell Gulch, in Russell Gulch below the confluence with Lake Gulch, and in Nevada Gulch below Nevadaville.

The selected remedy includes high- and low-flow sampling of North Clear Creek and main stem Clear Creek, to assess the effectiveness and protectiveness of the selected remedy (up and downstream of North Clear Creek) every other year.

The general locations of the sediment reduction components are shown in Figures 9.2 and 9.3. Details of the components are illustrated in Figures 9.5 and 9.6

The mine waste piles listed above for remediation or removal were chosen based on a ranking system described in Section 9.3.1. The decision to either cap or remove mine waste piles located along North Fork tributaries is based on the proximity of the pile to a watercourse, the aspect of the slope upon which the pile is present, and the pile chemistry. Two options have been developed for capping waste piles: 1) soil cap with vegetated cover, and 2) rock cap underlain by filter fabric. Additional location specific options could be developed in Remedial Design. For piles that are not situated well for capping, removal is proposed.

12.2.1.1 Mine Waste Pile Capping

The selection of a soil cap or a rock cap is dependent on the general slope aspect of the waste pile. Under either option, the waste pile slopes would be graded to a stable slope and the reach of stream channel near the waste pile would be stabilized. Run-on ditches would be constructed on the upslope sides of the waste piles to divert surface water around the capped mine waste piles. The general cap design concepts of both options are described below.

12.2.1.2 Mine Waste Pile Removal

Waste piles with a higher metals concentrations and a general southern slope aspect would be excavated and disposed at a mine waste repository or centralized mine waste pile located between Idaho Springs and Central City/Black Hawk, or disposed of at a landfill off-site . The excavated areas would be regraded and revegetated with a native seed mix unless excavated to bedrock.

12.2.1.3 Tributary Channel Stabilization

Select reaches of channels in Russell and Gregory Gulches with braided channels or unstable banks near the high and medium priority waste piles would be stabilized to reduce the further erosion of banks and mine wastes. During high-flow, waste piles could be undercut adjacent to the channel, thereby introducing more contaminated materials into the channel. Unstable channel banks would be graded and armored with riprap, retaining walls, gabions, or other erosion reducing technologies. Riprap will also be placed to line graded channel bottoms where necessary to control channel erosion.

12.2.1.4 Sediment Settling Basins

To address the transport of sediment and contaminated water from the Gregory and Russell Gulches, settling basins in these drainages are proposed due to the large sediment loads originating from these tributaries during the spring runoff and during storm events. The settling basins are intended to temporarily detain surface water, thereby allowing suspended sediment to settle out of the water column. The dams will be constructed so they are over-toppable during high-flows (i.e., greater than the 10-year, 24-hour event). The dams will be designed such that they can pass up to the 100-year event without losing then-structural integrity. A settling basin will be constructed upstream of the dam. Sediments accumulated in the settling basins will be periodically excavated and disposed of at an on-site mine waste repository or centralized mine waste pile, or off-site.

12.2.2 Water Treatment

The water collection, conveyance, and treatment components of the selected remedy include:

1. A ground water collection system utilizing an interceptor trench at the base of the Gregory Gulch alluvium near the upstream entrance of the Gregory Gulch box culvert through Black Hawk.
2. A sump and pump station on the upgradient side of the Gregory Gulch ground water collection system, and a pipeline connecting to the Bates Hunter Mine Water Treatment Plant.
3. A pump station and pipeline connecting the Gregory Incline discharge to the Bates Hunter Mine Water Treatment Plant.

4. A gravity pipeline configured as full-pipe flow conveying the National Tunnel discharge downstream to the passive treatment system location.
5. A passive treatment system consisting of SRBR cells and a FWS cell for polishing prior to discharge to the North Fork.

12.2.2.1 Active Treatment of the Gregory Incline Discharge and Gregory Gulch Ground Water
The Gregory Incline discharge and Gregory Gulch ground water will be pumped to the Bates Hunter Mine water treatment plant for treatment. One potential route would involve pumping the Gregory Incline discharge over the shotcreted wall on the western side of the Bullwackers Casino parking lot in a pipeline. The Gregory Gulch ground water pipeline would join the Gregory Incline pipeline, and the combined water would be pumped to the Bates Hunter Mine water treatment plant. The treated water would then be discharged either into Gregory Gulch or into the North Fork of Clear Creek, as determined in Remedial Design.

12.2.2.1 Passive Treatment System to Treat National Tunnel Discharge
The Sulfate Reducing Bioreactor (SRBR) cells comprise the first and main step in the passive treatment system that will treat the National Tunnel discharge. In these cells, the slow decay of organic matter and the by-products of sulfate reducing bacterial metabolism create conditions that neutralize acidity, provide excess alkalinity, and precipitate insoluble iron, copper, zinc, and cadmium sulfides and as-yet undetermined aluminum hydroxyl-sulfate compounds.

The entire passive treatment system, including the FWS cell, would span approximately two acres, would be situated outside of the 100 year floodplain of the North Fork, and would be located along Highway 119 approximately one to two miles downstream of Black Hawk.

It should be noted that the water treatment aspects of the selected remedy discussed above (i.e. the active treatment of the Gregory Incline discharge and the Gregory Gulch ground water, and the passive treatment of the National Tunnel discharge) involve restoration of surface water and/or ground water. Consequently, in accordance with CERCLA Section 104(c) and NCP Section 300.435(f), these and other restoration activities are considered remedial action for up to ten years. As such, EPA and CDPHE will share the cost of the water treatment for up to ten years, the details of which will be drawn up in a State Superfund Contract.

12.2.3 Institutional Controls

Land use controls would be implemented as part of this remedy. Land use controls would limit access to, or use of, the areas remediated through prior response actions. These include capped and consolidated waste piles, area with run-on or run-off controls, and water collection structures. Permanent measures to be considered would include legal or institutional mechanisms to provide notification that a Superfund remedy is in place and establish restrictions/requirements for future activities to maintain the integrity and effectiveness of the remedies. These mechanisms may include modifications to county and/or city zoning ordinances or the establishment of environmental covenants for individual properties. Land use and plan/proposals for future land use would be monitored and evaluated as part of the five-year review process.

12.2.4 Monitoring

The selected remedy will monitor the results of remediation work completed OU4 as well as to monitor remedial actions completed under OUs 1, 2, and 3 to determine their compliance with ARARs and to determine if the Remedial Action Objectives and Remediation Goals for the remedies are being met. The ability of the OU4 remedy to achieve the Remedial Action Objectives and Remediation Goals along the main stem of Clear Creek depends on the effectiveness of the OU4 remedy, as well as cleanup work to be done upstream within the basin of the main stem . If monitoring shows that the selected remedy does not comply with Remedial Action Objectives and/or Remediation Goals, CDPHE and EPA would evaluate whether additional remediation would be needed, if reconsideration of Remedial Goals would be warranted, and/or if an ARARs waiver would be appropriate. Five-Year Reviews will be used to evaluate the effectiveness of the remedies conducted under all OUs within the study area, including OU4.

12.2.5 Cost Estimate for the Selected Remedy

An itemized cost estimate for Alternative 4B, the selected remedy, is presented in Table 12.1. The present worth costs are estimated using a 7% discount rate over a 30 year time period.

12.2.6 Expected Outcomes of the Selected Remedy

CDPHE and EPA expect that, upon implementation of the remedial action and following a period of time allowing for the stabilization of in-stream sediment conditions, this remedy will protect human health and the environment, will comply with ARARs, and will achieve the Remedial Action Objectives.

It is expected that capping or removing priority waste piles which have the greatest probability to contribute to the sediment and/or metals loading of surface waters within OU4 will decrease the human health risk associated with exposure to waste piles. This remediation will also decrease the potential of these mine wastes to transport sediment to North Fork of Clear Creek, to generate contaminated run-off, or to contaminate ground water.

It is also expected that the treatment of major point sources of metals contamination such as tunnel discharges, and of non-point sources such as ground water, will reduce in-stream metals concentrations to levels that present acceptable risk to aquatic organisms. Consequently, this would allow brown trout to survive in the North Fork and, provided other upstream remediation within the main stem basin is successful, would support a viable reproducing brown trout fishery in the main stem of Clear Creek. This would also improve the overall water quality of the main stem of Clear Creek, benefitting the downstream water users such as the cities of Golden, Arvada, Northglenn, Thornton, and Westminster.

SECTION 13

STATUTORY DETERMINATIONS

Under CERCLA 121 and the NCP, the lead agency must select remedies that are protective of human health and the environment, comply with applicable or relevant and appropriate requirements (unless a statutory waiver is justified), are cost-effective, and utilize permanent solutions to the extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element and a bias against off site disposal of untreated wastes. The following sections discuss how the selected remedy meets these statutory requirements.

13.1 PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The selected remedy will protect human health and the environment by:

- Preventing unacceptable exposure risk to current and future human populations presented by ingestion of mine waste or inhalation of mine waste dust.

- Reducing the concentrations of COCs in North Fork surface water, through point and non-point source treatment, to an extent that enables brown trout to survive along the North Fork and that supports a reproducing brown trout fishery along the main stem of Clear Creek.

- Reducing the amount of metals-laden sediment that is transported to the North Fork through sediment controls such as the run-on controls, channel stabilization and capping or removal of waste piles along tributaries and the main stem of the North Fork.

- Reducing sediment and metal loads to the North Fork so that water quality is improved and sediment toxicity is reduced in both the North Fork and the main stem of Clear Creek.

13.2 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The selected remedy will comply with Federal and State ARARs that have been identified. A complete list of all ARARs identified for remedial actions at OU4 can be found in Tables 10.2, 10.3, and 10.4. No waiver of any ARARs is being sought for the selected remedy. Monitoring will be conducted, and the five-year reviews will be used, to confirm compliance with ARARs upon implementation of the selected remedy.

<u>Chemical-Specific ARARs</u>
Compliance of the selected remedy with all chemical-specific ARARs will be evaluated during the five-year reviews. It is expected that the selected remedy will comply with all chemical-specific ARARs for the North Fork, and will comply on the main stem segment 11 once the OU3 remedial actions in Virginia Canyon are completed. The point of compliance for these ARARs will be established and monitored through the implementation of long-term monitoring. The applicable or relevant and appropriate chemical-specific requirements identified for the OU4 remedial action include:

- Federal Water Pollution Control Act (Clean Water Act)
- National Primary Drinking Water Regulations
- Colorado Water Quality Control Act (Surface Water and Groundwater Regulations)
- Colorado Primary Drinking Water Regulations

<u>Action-Specific ARARs</u>
The selected remedy will comply with all action-specific ARARs. The ARARs identified for the OU4 remedial actions include:

- National Pollutant Discharge Elimination System (NPDES) Permit Regulations
- Federal Water Pollution Control Act (Clean Water Act), Section 404 Dredge and Fill Regulations
- Federal Resource Conservation and Recovery Act (RCRA) Solid and Hazardous Waste Regulations
- Federal Underground Injection Control (UIC) Regulations
- Colorado Discharge Permit System
- Colorado Solid Waste Regulations
- Colorado Hazardous Waste Regulations
- Colorado Noise Abatement Act
- Colorado Environmental Real Covenants Act

<u>Location-Specific ARARs</u>
The selected remedy will comply with all location specific ARARs. The ARARs identified for the OU4 remedial actions include:

- Executive Order No. 11900, Protection of Wetlands
- Executive Order No. 11988, Floodplain Management
- Section 404 of the Clean Water Act
- National Historic Preservation Act
- Historic and Archeological Data Preservation Act of 1974
- Executive Order 11593, Protection and Enhancement of the Cultural Environment
- Archeological Resources Protection Act of 1979
- Endangered Species Act
- Fish and Wildlife Coordination Act
- Migratory Bird Treaty Act
- Executive Order No. 12962, Recreational Facilities
- Colorado Solid Waste Disposal Sites and Facilities Act
- Historic Places Register
- Colorado Non-game, Endangered, or Threatened Species Act
- Colorado Wildlife Act

Several regulations pertaining to the preservation of historic features have been identified as ARARs. Compliance will be achieved through implementation of procedures to preserve historical and archeological data should qualifying historical features be affected by the remedy.

13.3 COST-EFFECTIVENESS

In CDPHE's and EPA's judgment, the selected remedy is cost-effective and represents a reasonable value for the money to be spent. In making this determination, the following definition was used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness (NCP 300.430(f)(l)(ii)(D))-" This was accomplished by evaluating the "overall effectiveness" of those alternatives that satisfied the threshold criteria (i.e. were both protective of human health and the environment and ARAR-compliant). Overall effectiveness was evaluated by assessing three of the five balancing criteria in combination (long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness). Overall effectiveness was then compared to costs to determine cost-effectiveness. The relationship of the overall effectiveness of the selected remedy was determined to be proportional to its costs, and hence this alternative represents a reasonable value for the money to be spent.

The estimated present worth cost of the selected remedy is $23,329,000.

13.4 UTILIZATION OF PERMANENT SOLUTIONS AND ALTERNATIVE TREATMENT (OR RESOURCE RECOVERY) TECHNOLOGIES TO THE MAXIMUM EXTENT PRACTICABLE (MEP)

CDPHE and EPA have determined that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at OU4. Of those alternatives that are protective of human health and the environment and comply with ARARs, CDPHE and EPA have determined that the selected remedy provides the best balance of trade-offs in terms of the five balancing criteria, while also considering the statutory preference for treatment as a principal element and bias against off-site disposal and considering State and community acceptance.

The large volume of mine wastes precludes treatment or off-site disposal as a viable option. In addition, the mine waste does not contain resources that may be recovered economically at the present time. However, the potential remains for reprocessing of mine waste in the future should it become economically viable.

13.5 PREFERENCE FOR TREATMENT AS A PRINCIPAL ELEMENT

The selected remedy includes treatment of mine wastes including tunnel discharges and nonpoint sources of metals contamination.

13.6 FIVE-YEAR REVIEW REQUIREMENT

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining in OU4 above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after construction and implementation of remedial action to ensure that the remedy remains protective of human health and the environment.

Appendix C

Responsiveness Summary

This Appendix C contains the responses of the Colorado Department of Public Health and Environment (CDPHE), Hazardous Materials and Waste Management Division (HMWMD) and US Environmental Protection Agency Superfund Program (EPA) to comments received concerning the Operable Unit 4 Proposed Plan and Feasibility Study. This Appendix summarizes the comments received, and provides responses. The original comments are on file at the Site information repositories located at the Agencies, and are available for public review.

The official public comment period for the Feasibility Study and Proposed Plan extended from July 23, 2004 to August 23, 2004. An advertised public meeting was held in Central City at the Gilpin County Courthouse on August 11, 2004 to summarize the proposed plan and to hear comment on the Proposed Plan and Feasibility Study. The proceedings of this meeting were recorded by a stenographer and are also available for public review at the Site information repositories located at the CDPHE and EPA offices. The proposed plan was also presented at a meeting of the Gilpin County Commissioners on August 3, 2004.

A presentation regarding the Feasibility Study and proposed plan options was made to the Upper Clear Creek Watershed Association on June 10, 2004. Prior presentations were made to the Upper Clear Creek Watershed Association in August and November 2002 regarding the Remedial Investigation, and in Fall 2003 regarding the alternative modeling results and a presenting a preview of the Feasibility Study.

Several commenting parties specifically expressed support for the preferred clean up plan as submitted in the Proposed Plan (Alternative 4B). Commenters supporting the preferred alternative included the City of Golden, the Town of Empire, the City of Northglenn, Black Hawk and Central City Sanitation District, the Clear Creek Watershed Foundation, the Upper Clear Creek Watershed Association, the Colorado Division of Wildlife, a private individual, and Gilpin County. The membership represented by the Upper Clear Creek Watershed Association includes the Black Hawk/Central City Sanitation District, the Central Clear Creek Sanitation District, the City of Black Hawk, Central City, the City of Golden, the City of Idaho Springs, Clear Creek Ski Corporation, Gilpin County, the Henderson Mine (Phelps Dodge Corp), Jefferson County, Saint Mary's Glacier Water and Sanitation District, Clear Creek County, the Town of Silver Plume, the Town of Empire, Shwayder Camp, the Town of Georgetown, the Colorado Department of Transportation, Coors Brewing Company, Saddleback Ridge, and Mount Vernon Country Club Metro District.

CDPHE would like to thank all of the people who took the time to review and comment on the various documents that have been released for comment. CDPHE would especially like to thank the Upper Clear Creek Watershed Association, which, collectively and though efforts of many of its individual members, has participated in the Superfund process and provided invaluable input and comment to CDPHE and EPA which has had a great influence on the approach and content of the Remedial Investigation, Feasibility Study, Proposed Plan and Record of Decision.

SPECIFIC COMMENTS

COMMENT: A downstream water user noted their support for cooperative efforts that improve the water quality of Clear Creek. It was noted that Clear Creek is their drinking water source and a vital economic and recreational benefit to the community.

RESPONSE: Clear Creek and North Clear Creek are upstream of the Cities of Golden, Arvada, Westminster, Northglenn and Thornton which all use Clear Creek water as a drinking water source. The remedial action objectives for OU4 include the objective to "ensure that in-stream metals concentrations do not degrade drinking water supplies diverted from the main stem Clear Creek."

COMMENT: The Clear Creek Watershed Foundation suggested a stronger case be presented that remedial actions within the basin address concerns of public health, safety and welfare, rather than relying only on objectives of aquatic life.

RESPONSE: The remedial objectives contained in the Feasibility Study and the Record of Decision include aquatic life based objectives for Clear Creek and the North Fork of Clear Creek. In addition, objectives addressing downstream drinking water supplies and protection from potential human health exposures related to mine waste piles are included in the remedial action objectives. Improvements to the water quality of Clear Creek and the North Fork of Clear Creek will have the direct benefit of increased viability and protection of aquatic life within the streams, which will in turn facilitate habitat and riparian corridor improvements. The improvements will also provide source water improvements and protection to the drinking water source used by the Cities of Golden, Arvada, Westminster, Northglenn and Thornton. Because these cities take measures to treat and otherwise assure the water they supply to their customers is safe and of the highest quality possible, CDPHE and EPA have not proposed Superfund actions, past and current, be justified solely based on downstream water uses. The mine waste pile capping, channel stabilization and stream bank stabilization included in the selected remedy will also reduce the potential for slides and slope failures. CDPHE and EPA agree that improvement to water quality and actions to improve and protect water quality in Clear Creek have far reaching broad benefits to public health safety and welfare of many citizens that are sometimes not given the emphasis that aquatic life objectives receive because the benefits are perhaps more difficult to directly quantify. These benefits extend to increased recreational opportunities, and will also foster habitat, riparian corridor, and land use improvements.

COMMENT: The Clear Creek Watershed Foundation suggested that the first repository should be developed at the Gem/Franklin site, noting that they believe hauling sludge and other wastes into other environments for disposal is hazardous and wasteful.

RESPONSE: While not directly addressed by the OU 4 Record of Decision and Feasibility Study, the Agencies have been pursuing construction of a mine waste repository which could be used for disposing of mine waste pile material and water treatment plant sludges generated by local Superfund projects such as the Argo Tunnel treatment plant in Idaho Springs. The Agencies have proposed a repository to reduce cost and distance of travel for disposal of such materials, to maximize program efficiencies, and to facilitate a more efficient means of addressing mine wastes than hauling them to landfills located on the front range. The proposed repository would utilize the high pH base characteristic of the sludges to counteract and neutralize the acidic low pH characteristic of mine waste pile material. CDPHE and EPA have been pursuing constructing a repository at the Druid site, the location of the former Solution Gold operation. The Agencies have not obtained the necessary property rights or been able to secure an appropriate agreement with the owner of the Druid site to proceed with the repository at that location. CDPHE and EPA are currently continuing to pursue constructing the repository at the Druid site. However, this comment is duly noted, and options for other sites such as the Gem/Franklin site are also being considered.

COMMENT: The Clear Creek Watershed Foundation noted their support for additional non-point source work beyond that called for by the OU4 Feasibility Study and Proposed plan.

RESPONSE: Superfund efforts including those called for by the OU 4 Record of Decision are intended to address only the most significant impacts of historic mine wastes with the objective of attaining the stated remedial action objectives. These objectives include water quality improvements along the North Fork and main stem of Clear Creek, and the protection of human health and the environment. The watershed is a complex basin with many mine waste sources including both discrete point sources and numerous non-discrete non-point sources that are not proposed to be addressed by the Superfund efforts. Efforts to address additional nonpoint sources within the basin will be important to the ongoing cooperative efforts within the watershed to foster continuing sustainable improvements to water quality and to the revitalization of impacted lands.

COMMENT: The Colorado Division of Wildlife (CDOW) raised concern about using the Argo Tunnel water treatment plant to treat mine waters from the North Fork of Clear Creek basin because of concerns about possible negative impacts to the main stem of Clear Creek. CDOW supports the preferred alternative, Alternative 4B, and then would support alternative 3B, which would involve a new treatment facility within the North Fork of Clear Creek basin as its second choice. CDOW has concerns with Alternatives 3 A and 3C because they propose using the Argo Tunnel treatment plant to treat mine waters from the North Fork of Clear Creek basin.

RESPONSE: CDPHE and EPA believe the remedial alternatives that involve using the Argo Treatment plant to treat the mine water from the North Fork of Clear Creek could be implemented without negative impacts to Clear Creek. Prior to implementing Alternatives 3 A or 3C there would need to be confirmation of the interconnection of mine workings and the ability to transport the water from the North Fork basin via the Argo Tunnel. The Argo treatment facility would need to be evaluated regarding its ability to handle the additional flow of water from the Gregory Incline, the National Tunnel and Quartz Hill. The Feasibility Study estimated upgrades of approximately 3 million dollars would be implemented at the Argo facility to address the routine additional flow. The most difficult potential impact to assess and address would be whether using the Argo Tunnel as a conveyance would unacceptably increase the risk of a tunnel surge which would require by-pass of the treatment facility and would adversely impact Clear Creek. The Argo facility currently has limited surge protection. Surge protection could be addressed by partial tunnel rehabilitation and installation of a surge control flow-through tunnel plug. Separate from the upgrade costs for handling the routine increased flow noted above, the estimated capital cost of tunnel rehabilitation and a flow-through plug is also 3 million dollars. Tunnel rehabilitation and flow-through runnel plugging were not included in cost estimates for Alternates 3A and 3C. Based on the information evaluated to date, CDPHE and EPA consider Alternatives 3A and 3C to be viable, technically feasible, and implementable alternatives. However alternative 4B was determined to provide better balance of the nine criteria and was thus selected in the Record of Decision.

COMMENT: The Upper Clear Creek Watershed Association suggested incorporating the remedial action objective of brown trout survival for segment 13b explicitly in the remedial action objective rather than in the comments following the statement of the remedial action objective.

RESPONSE: The remedial action objective for segment 13b has been modified to explicitly include the objective of survival of brown trout for segment 13b (North Fork of Clear Creek).

COMMENT: The Upper Clear Creek Watershed Association raised the concern over whether the remediation goals for zinc and copper are sufficiently protective considering Division of Wildlife recommendations for instances where elevated concentrations of both zinc and copper are present. The comment requests that after remediation is implemented, the appropriateness of the zinc remediation goals be reevaluated based on whether the goal for brown trout reproduction and/or survival are met. If in the future the remediation goals are not met, Upper Clear Creek Watershed suggests additional remediation should be performed to meet the brown trout goals. They would ultimately like to see a reproducing brown trout population in North Fork.

RESPONSE: For both the main stem of Clear Creek and for the North Fork of Clear Creek, achievement of the remedial action objectives is more important than achieving the numeric remediation goals because remediation goals are set to facilitate achieving the remedial action objectives. Therefore, the success and protectiveness of the remedy would be based first and foremost on whether the remedy results in a surviving brown trout population on the segment 13b of the North Fork of Clear Creek and a viable reproducing brown trout on segment 11 of the main stem of Clear Creek. We agree there is some uncertainty as to the synergistic effects of zinc and copper. Therefore the Agencies agree with the Upper Clear Creek Watershed Association's suggestion that the remediation goals be reevaluated based on whether the remedial action objectives of brown trout reproduction and/or survival are attained by the remedial action. Following the implementation of remedial action, the effectiveness will be assessed based on whether the remedial action objectives and remediation goals are attained. If they are not attained, consideration of either additional remedial action and/or some modification of the remediation goals may be warranted. In the future, one purpose of the five-year review process, required by CERCLA, will be to assure such evaluations are performed and to facilitate the Agencies review of whether the remedial action achieves its objectives and is protective of human health and the environment. The remediation goals that were selected are acknowledged to be based on a balance between concentrations that are projected to be reasonably achievable given the proposed remedial alternatives and considering various hardness-based toxicity recommendations of the Division of Wildlife. The Division of Wildlife recommendations are based on Clear Creek-specific information, research and data from other streams, and laboratory studies. It should be noted that North Fork of Clear Creek has very high hardness compared to most streams, making correlations to other steams and to the main stem of Clear Creek difficult.

COMMENT: The Upper Clear Creek Watershed Association (UCCWA) supports the Feasibility Study and Proposed Plan approach of using a seasonal approach to set remediation goals. The commenter points out that the Water Quality Control Division (WQCD) has calculated Table Value Standards for Clear Creek using an average hardness, not a seasonal hardness as was done by the Feasibility Study and Proposed Plan. The comment notes that the preliminary remediation goals for low flow would therefore not be as stringent as WQCD water quality standards calculated based on nonseasonal average hardness, and suggests the Record of Decision should identify this as an issue to be addressed during the next triennial review by the WQCD. Additionally UCCWA hopes that the CDPHE Hazardous Materials and Waste

Management Division and EPA will support a seasonal approach to water quality standards for these segments (11 and 13b).

RESPONSE: The Feasibility Study and Record of Decision's use of the seasonal standards is indication of the Hazardous Materials and Waste Management Division's and EPA Superfund Program's belief that use of seasonal standards for the metals of concern to the Superfund work is appropriate. Within CDPHE, Hazardous Materials and Waste Management Division (HMWMD) is delegated the implementing authority for complying with water quality standards for CERCLA remedial actions. The associated interpretations are done in consultation with the WQCD but do not need to be affirmed by the Water Quality Control Commission (WQCC) as is the case for permit and modifications to stream standards for permitted entities. In the Record of Decision and through the Applicable and Relevant and Appropriate Requirements (ARARs), HMWMD determined that for the proposed CERCLA actions and the specific metals of concern, use of a seasonal approach is compliant with the applicable water quality standards. While other regulated parties may not have the ability to make such interpretations, they will have the opportunity, either site specifically or, during the next triennial review, to request to use a similar approach. We believe it would be inappropriate for HMWMD to suggest to WQCD and WQCC the means of implementing water quality standards on other than CERCLA matters. Use of seasonal standards was reviewed by WQCD and concurred with as appropriate for the proposed CERCLA actions.

COMMENT: Gilpin County comments supported aggressive sediment controls, and the Upper Clear Creek Watershed Association supported Tier 2 sediment controls, which include both tributary and North Fork of Clear Creek sediment controls.

RESPONSE: Modeling and predictions of the effectiveness of the various alternatives indicated that the alternatives that included sediment control on both the tributaries and on North Fork of Clear Creek (4B and 3C) would offer the greatest likelihood of achieving the remediation goals and remedial action objectives. Alternatives that included the less aggressive Tier 1 sediment controls would potentially have difficulty meeting low flow zinc remediation goals, which are critical to attaining the remedial action objectives. This is one of the main reasons alternatives 4B and 3C achieved the highest ranking for overall protection of human health and the environment and compliance with ARARs (which are threshold criteria), and was an important consideration in proposing and selecting Alternative 4B as the selected remedy.

COMMENT: The Upper Clear Creek Watershed Association and the Clear Creek Watershed Foundation support the completion of the repository.

RESPONSE: Although not specifically included as a remedial measure called for by the OU4 Record of Decision, the Agencies continue to pursue implementation of an on-site mine waste repository. Efforts to implement the repository are being made as a part of the remaining and ongoing OU3 work. If the Agencies are successful in implementing a repository, it will increase the efficiencies of cleanup for OU4 as well as OU3.

COMMENT: The Upper Clear Creek Watershed Association and a private individual commenter caveat their support of the selected alternative. They note concern about the limited capacity of the Bates Hunter treatment facility, both ongoing and also during initial mine dewatering. In addition, concern over the future effectiveness of passive treatment was noted.

RESPONSE: The Upper Clear Creek Watershed Association raises a good point that the Bates Hunter facility will not have much excess capacity. Modeling of the anticipated effectiveness of the selected alternative is based on treating 100% of Gregory Incline flow, 100 % of the National Tunnel and the base flow of Gregory Gulch ground water during low flow conditions (September through April). Load reductions for these sources were assumed to be 99% for Gregory Incline (active treatment), 85% for National Tunnel (lower because of the passive system) and 25% for Gregory Gulch (treatment would be effective but limited by the ability to collect non-point sources). In the high flow setting, the loading reduction for the Gregory Incline was assumed to be only 85%, instead of 99%, to model and account for the potential that the Bates Hunter treatment plant capacity is limited and flow capacity may be exceeded some during high flow conditions. With the exception of copper, all North Fork remediation goals are anticipated to be achieved during high flow. Ideally, a higher flow capacity for water treatment system would be available. However, estimates for the cost of constructing a new treatment facility in the North Fork basin were much higher than for the public/private cooperative treatment using the Bates Hunter treatment facility. Based on overall evaluation of the nine criteria it was determined that Alternative 4B, which uses the Bates Hunter, would provide a better balance of the nine criteria than the alternative that includes constructing a larger capacity new facility. During initial mine dewatering, treatment capacity may indeed be more limited than of other times. For this reason, the Agencies will consider performing initial dewatering of the Bates Hunter mine during low flow, when other water sources are minimized. Other options such as temporary treatment at lower pH in order to increase the ability to handle greater water flow could be considered. The details of the relationship between the Bates Hunter mine dewatering and treatment of the Gregory Incline and Gregory Gulch waters has not been resolved. The comments raised by the Upper Clear Creek Watershed Association raise valid concerns that will be considered as such plans are made.

With respect to passive treatment, CDPHE and EPA believe that an effective passive treatment system can be constructed and operated. After implementation of the remedy and following the initiation of operations, the Agencies will have a much better sense of the vulnerabilities of the system and of the flow and capacity limitations. Success will ultimately be determined primarily by whether the remedial action objectives are attained. Initially, the effectiveness of the selected alternative would be assessed, and later the five-year review process is intended to identify whether the remedy remains protective. If it is determined that a remedy is not effective, it may lead to additional remedial action or may lead to reconsideration of the remedial action decisions made in the Record of Decision.

COMMENT: The Upper Clear Creek Watershed Association and an individual commenter specifically support the water treatment of Gregory Incline, Quartz Hill Tunnel and the National Tunnel, as well as supporting a water treatment solution that discharges treated water to the North Fork.

RESPONSE: The Feasibility Study shows that water treatment of the main point sources is an essential component for any alternative to achieve remedial action objectives and remediation goals. Without treatment, the sediment efforts alone provide only limited improvements. Treating and discharging to the North Fork basin will maintain the flow of the mine tunnels in the North Fork of Clear Creek. The mine tunnels contribute as much as 15% of the flow of the North Fork of Clear Creek during low flow. This water will dilute remaining in-stream metals concentrations, and will help maintain a larger minimum base flow than would be the case if the tunnels are treated at the Argo Tunnel plant. The selected alternative also provides additional hardness to the North Fork of Clear Creek that will temper the toxicity of metals slightly. For these reasons, alternatives that treat water and discharge it to the North Fork of Clear Creek basin rather than conveying the water to the Argo Tunnel are more protective of the North Fork of Clear Creek than remedies that utilize the Argo treatment facility for treatment.

COMMENT: The Upper Clear Creek Watershed Association supports additional work in Virginia Canyon and on the main stem of Clear Creek

RESPONSE: While beyond the scope of the areas addressed by OU4, the agencies acknowledge the Association's concerns. Ongoing actions that will foster additional improvements along the main stem, including the Superfund work to contain and treat Virginia Canyon ground and surface waters, are important to achieve remedial action objectives and remediation goals on the lower reaches of the main stem of Clear Creek. The OU4 Feasibility Study shows that simply addressing the North Fork alone will not be sufficient to achieve remedial action objectives on the main stem of Clear Creek. Following implementation of the Virginia Canyon ground and surface water remedy, the Agencies will be able to assess the effectiveness of these actions to protect the main stem of Clear Creek, and to assess the extent of additional Virginia Canyon or other cleanup that may be warranted.

COMMENT: Comment was received from a private individual regarding potential ownership and knowledge of certain mine workings.

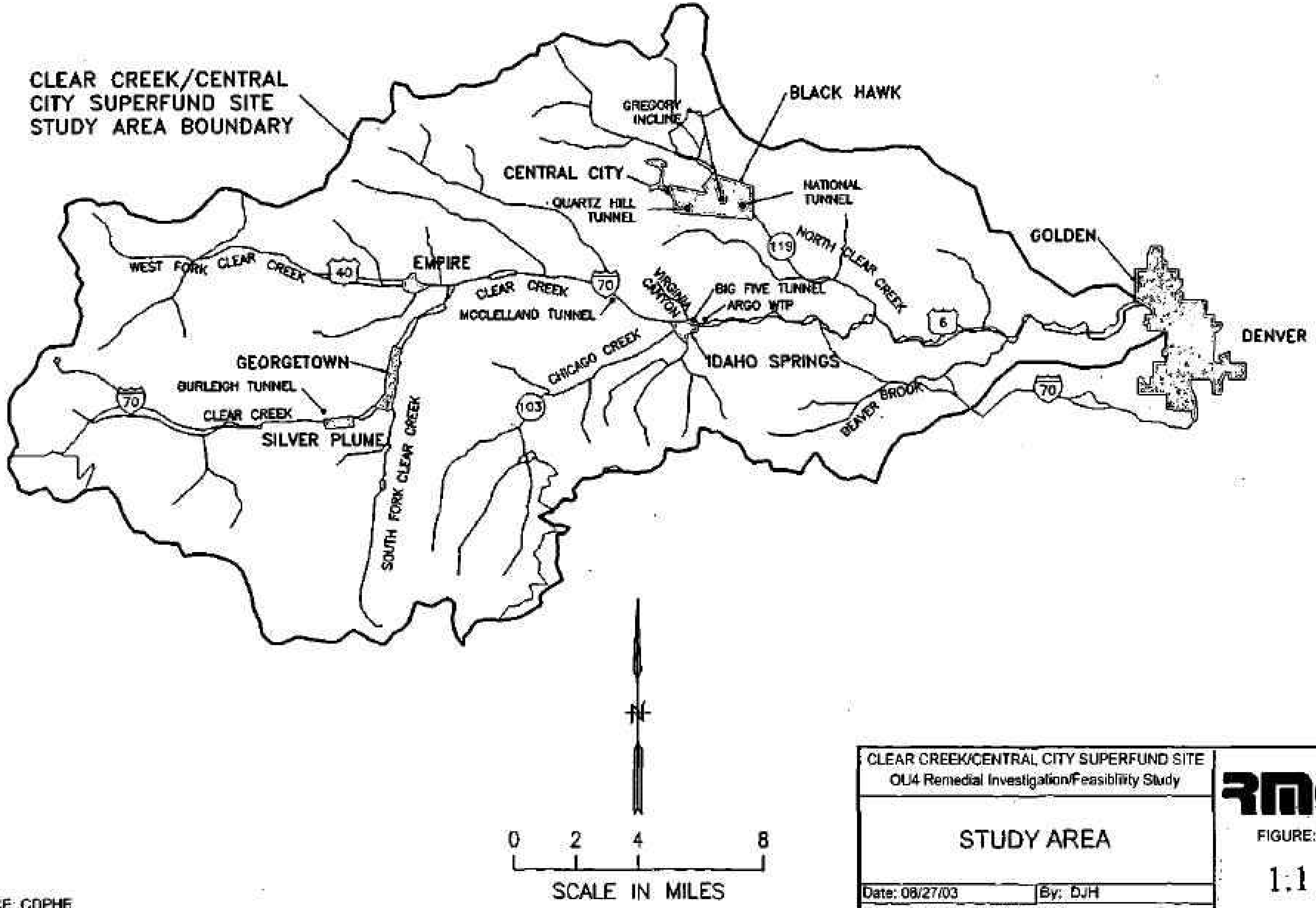
RESPONSE: This comment is noted and will be considered as remedial efforts proceed.

COMMENT: The Colorado Historical Society noted Section 106 consultations and reviews will be required and noted that the Central City/Black Hawk National Historic Landmark District and the Argo Tunnel are within the project area.

RESPONSE: The Agencies agree that coordination with the Colorado Historic Society will be required to assure compliance with applicable requirements. The Agencies plan to consult and coordinate with the Colorado Historical Society as remedial actions are implemented.

Appendix A

Figures for the Record of Decision



SOURCE: CDPHE

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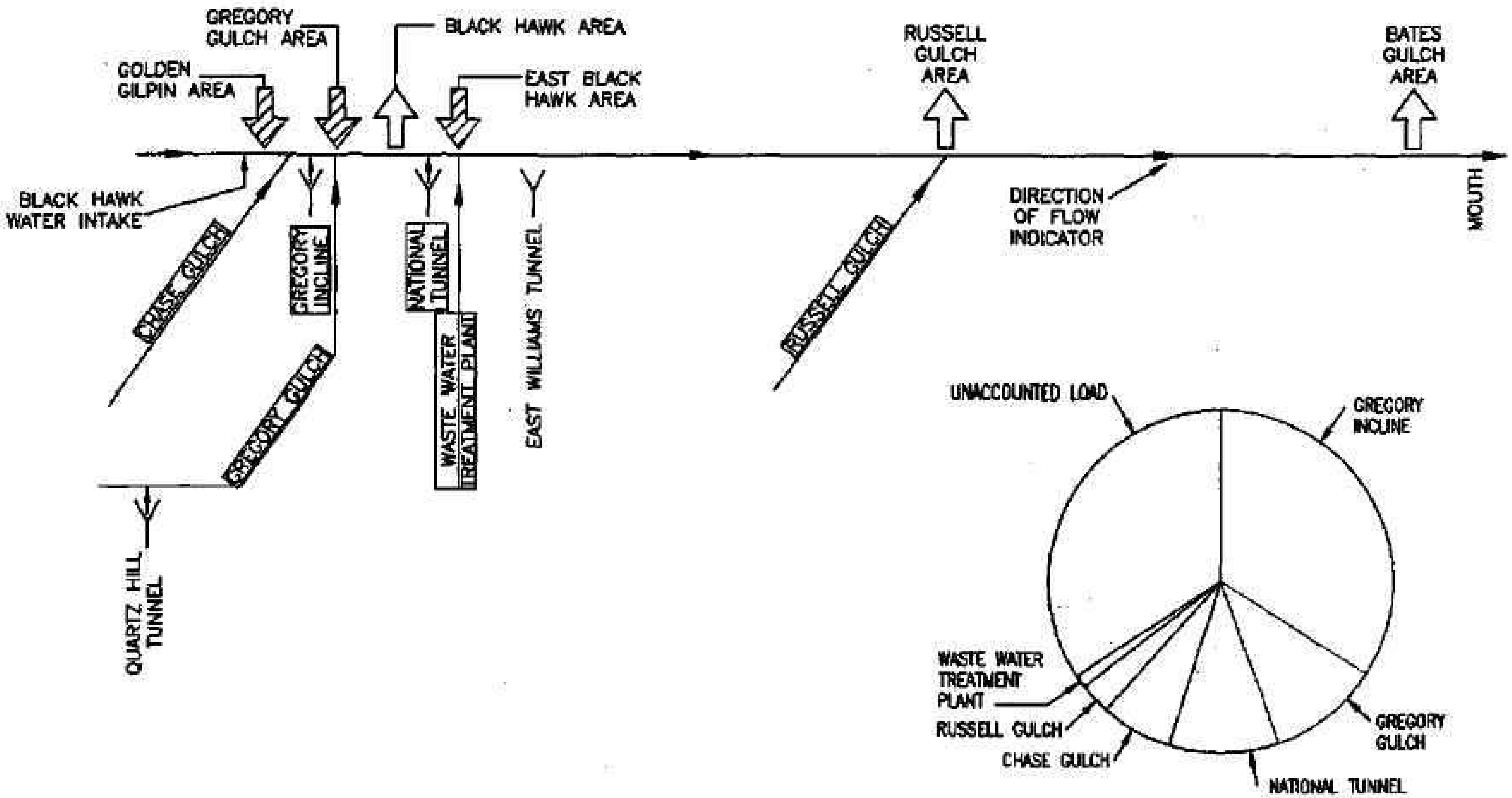
CLEAR CREEK/CENTRAL CITY SUPERFUND SITE OU4 Remedial Investigation/Feasibility Study		RMC
STUDY AREA		FIGURE:
Date: 08/27/03	By: DJH	1.1
File: R:11149_033.BTM\RI\STUDYAREA.DWG		



APPROXIMATE SOURCE CONTRIBUTION TO SUM OF LOADS MEASURED ALONG NORTH CLEAR CREEK

LEGEND

GENERAL AREA OF NON-POINT SOURCE METALS LOAD LOSS

GENERAL AREA OF NON-POINT SOURCE METALS LOAD GAIN

NOTES

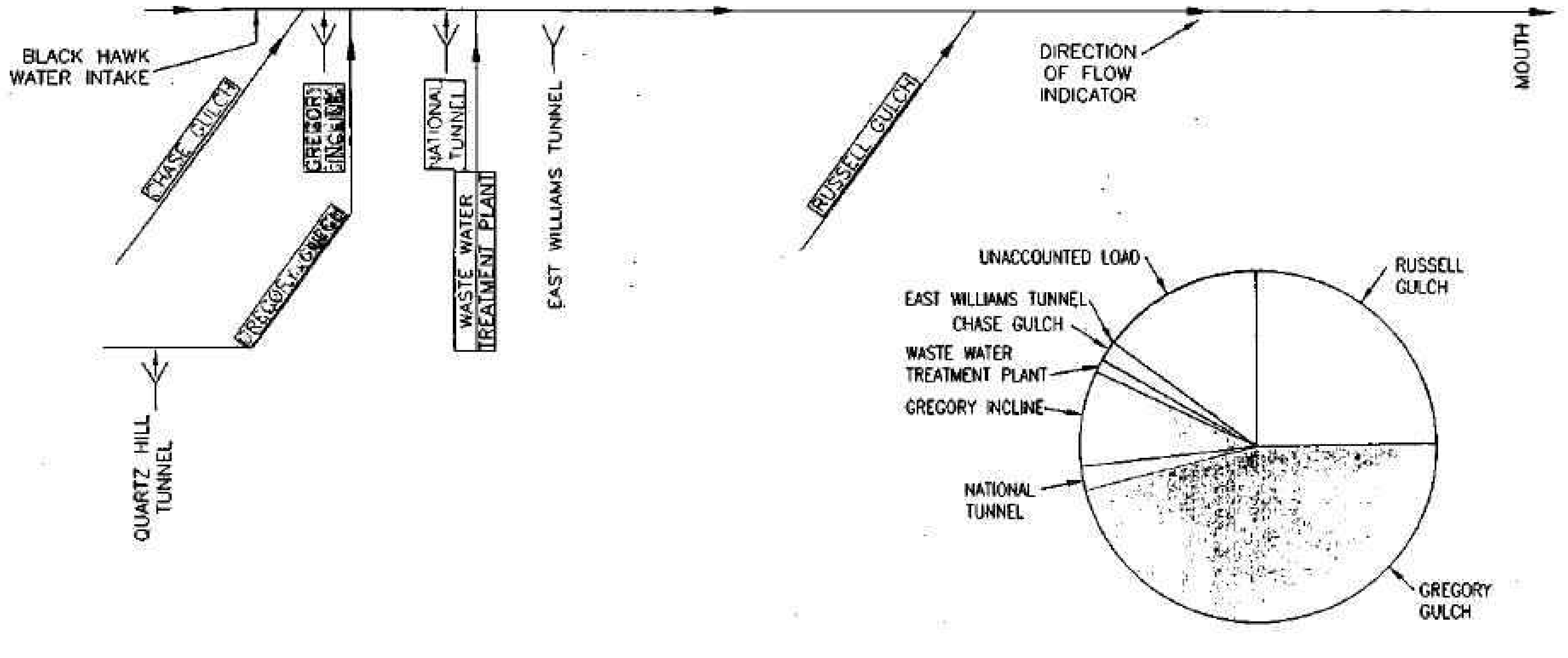
1. QUARTZ HILL TUNNEL LIKELY COMPRISES A LARGE PORTION OF THE LOADS MEASURED IN GREGORY GULCH.
2. THE EAST WILLIAMS TUNNEL CONTRIBUTES LESS THAN ONE PERCENT OF THE TOTAL LOADS.
3. THE SOURCE CONTRIBUTION PIE CHART IS BASED ON AVERAGE COPPER AND ZINC LOADING.

CLEAR CREEK/CENTRAL CITY SUPERFUND SITE
Remedial Investigation/Feasibility Study

CONCEPTUAL METAL LOADING MODEL OF NORTH CLEAR CREEK UNDER LOW-FLOW CONDITIONS

Date: 08/28/03 | By: DJH

FIGURE: 5.1



APPROXIMATE SOURCE CONTRIBUTION TO SUM OF LOADS MEASURED ALONG NORTH CLEAR CREEK

NOTES

1. QUARTZ HILL TUNNEL LIKELY COMPRISES A LARGE PORTION OF THE LOADS MEASURED IN GREGORY GULCH.
2. THE EAST WILLIAMS TUNNEL CONTRIBUTES LESS THAN ONE PERCENT OF THE TOTAL LOADS.
3. THE SOURCE CONTRIBUTION PIE CHART IS BASED ON AVERAGE COPPER AND ZINC LOADING.

JOB NO:19-1149.033.00

CLEAR CREEK/CENTRAL CITY SUPERFUND SITE Remedial Investigation/Feasibility Study	RMC
CONCEPTUAL METAL LOADING MODEL OF NORTH CLEAR CREEK UNDER AVERAGE HIGH-FLOW CONDITIONS	FIGURE: 5.2
Date: 08/29/03 By: DJH	
Source: F:\1149_033\RI\Surface_Water\Conceptual_Model.xls	

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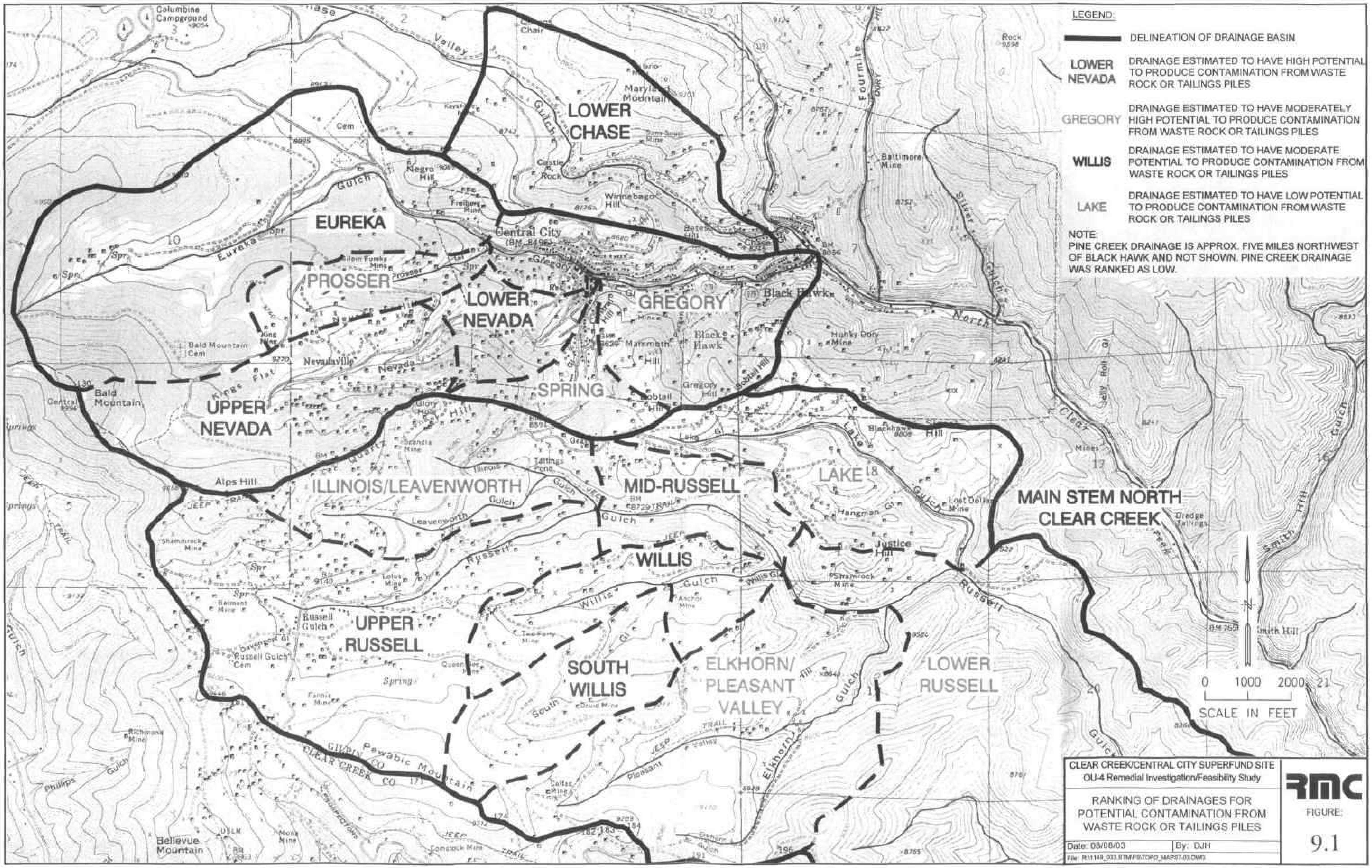

CLEAR CREEK/CENTRAL CITY SUPERFUND SITE
OU-4 Remedial Investigation/Feasibility Study

RANKING OF DRAINAGES FOR POTENTIAL CONTAMINATION FROM WASTE ROCK OR TAILINGS PILES

RMC

FIGURE: 9.1

Date: 08/08/03 By: DJH

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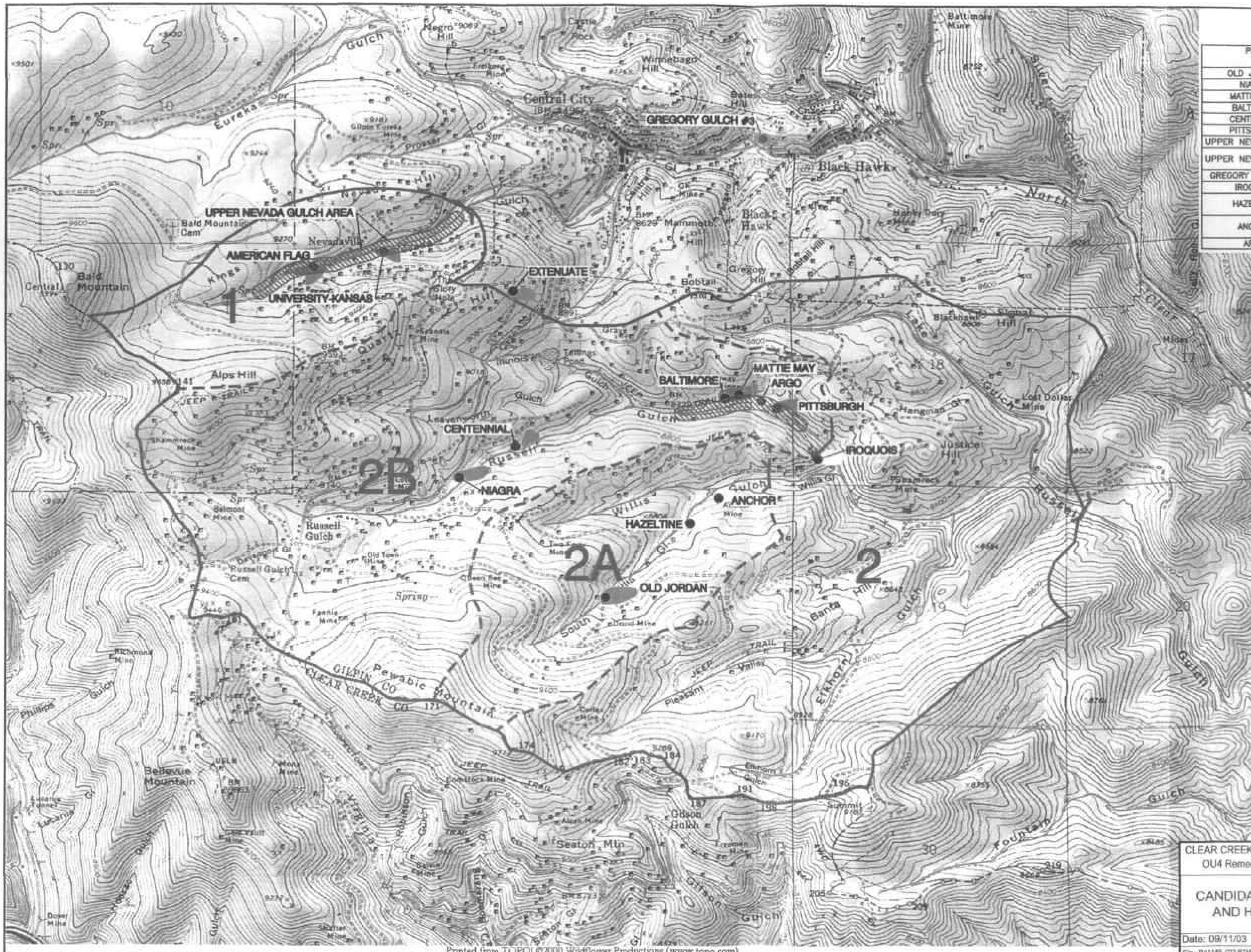
Color Map(s)

The following pages contain color that does not appear in the scanned images.

To view the actual images, please contact the Superfund Records Center at (303) 312-6473.



CLEAR CREEK WASTE PILE REMEDIAL OPTIONS

PILE	PRIORITY RANK	SLOPE ASPECT	CHEMICAL RATING	REMEDIAL OPTION
OLD JORDAN	HIGH	NORTH	HIGHER	REMOVE
NIAGRA	HIGH	SOUTH	HIGHER	REMOVE
MATTIE MAY	HIGH	SOUTH	HIGHER	CAP WITH ROCK
BALTIMORE	HIGH	SOUTH	HIGHER	CAP WITH ROCK
CENTENNIAL	HIGH	SOUTH	HIGHER	REMOVE
PITTSBURGH	HIGH	SOUTH	LOWER	CAP WITH ROCK
UPPER NEVADA GULCH	HIGH	SOUTH		CAP WITH ROCK
UPPER NEVADA GULCH	HIGH	NORTH		SOIL CAP AND REVEGETATE
GREGORY GULCH #3	HIGH	SOUTH	HIGHER	REMOVED
IROQUOIS	MEDIUM	SOUTH	LOWER	CAP WITH ROCK
HAZELTINE	MEDIUM	NORTH		SOIL CAP AND REVEGETATE
ANCHOR	MEDIUM	NORTH	LOWER	SOIL CAP AND REVEGETATE
ARGO	MEDIUM	NORTH	LOWER	CAP WITH ROCK

EXPLANATION

- PROPOSED SETTLING BASIN
- HIGH PRIORITY WASTE PILE
- MEDIUM PRIORITY WASTE PILE
- LOW PRIORITY WASTE PILE
- GENERAL AREA OF MINE WASTES ADJACENT TO/IN STREAM CHANNEL
- HYDROLOGIC BASIN OUTLINE
- HYDROLOGIC SUB-BASIN

NOTES:

1. MINE WASTE PILE LOCATIONS WERE OBTAINED FROM WILDEMAN, ET AL. (2003).
2. HAZELTINE MINE WASTE PILE LOCATED BY DESCRIPTION FROM SIMS, DRAKE AND TOOKER (1963).
3. OLD JORDAN MINE WASTE PILE LOCATED APPROXIMATELY 200' TO NORTHWEST FROM GIVEN GPS COORDINATES BASED ON DESCRIPTION IN WILDEMAN ET AL. (2003).

N

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SCALE IN FEET

JOB NO:18-1149.033.00

CLEAR CREEK/CENTRAL CITY SUPERFUND SITE
OU4 Remedial Investigation/Feasibility Study

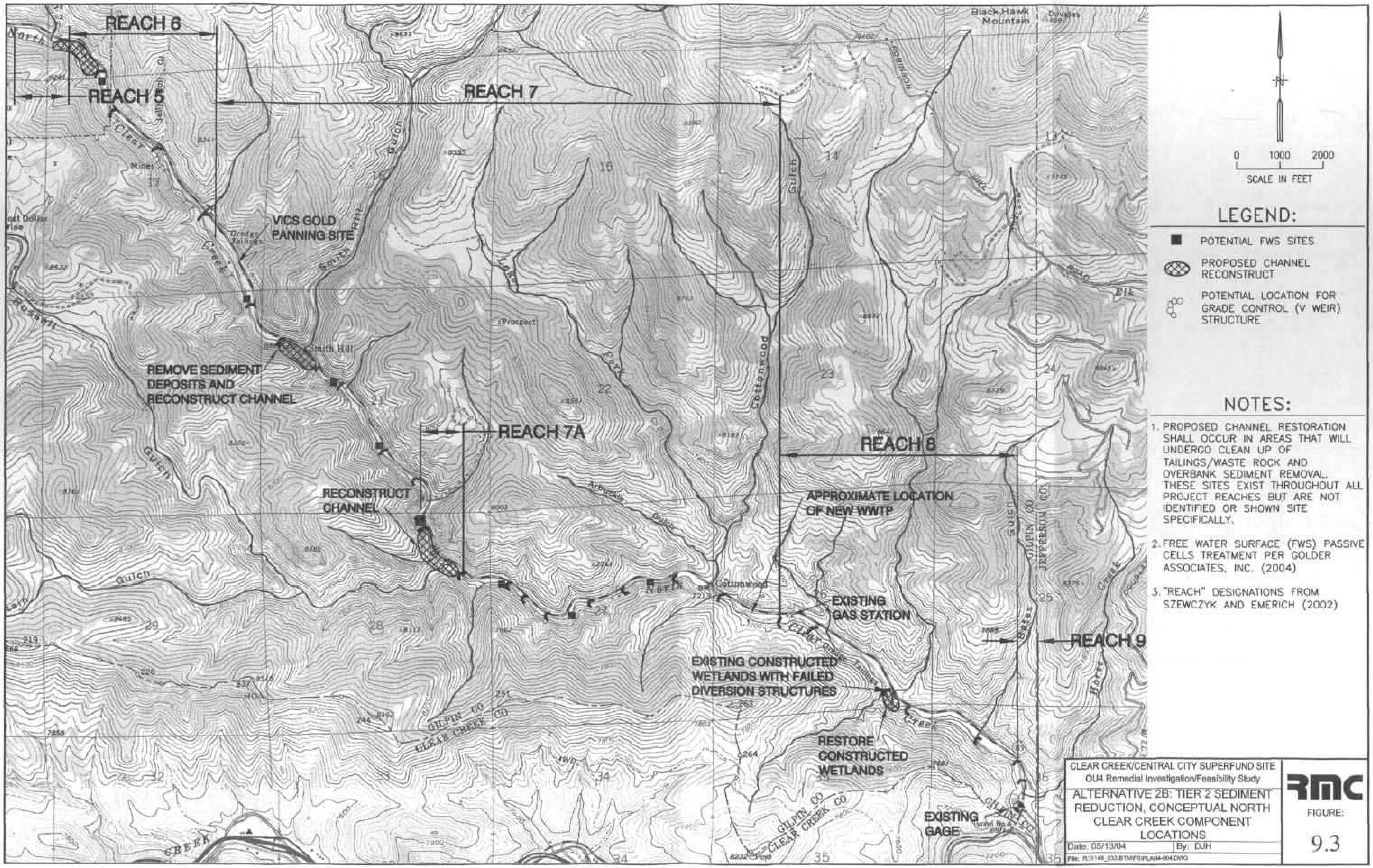
CANDIDATE MINE WASTE PILES AND HYDROLOGIC BASINS

Date: 09/11/03 | By: DJH

File: R31148_033.BTM\FIB\WASTE_ROCK.DWG

RMC

FIGURE: 9.2



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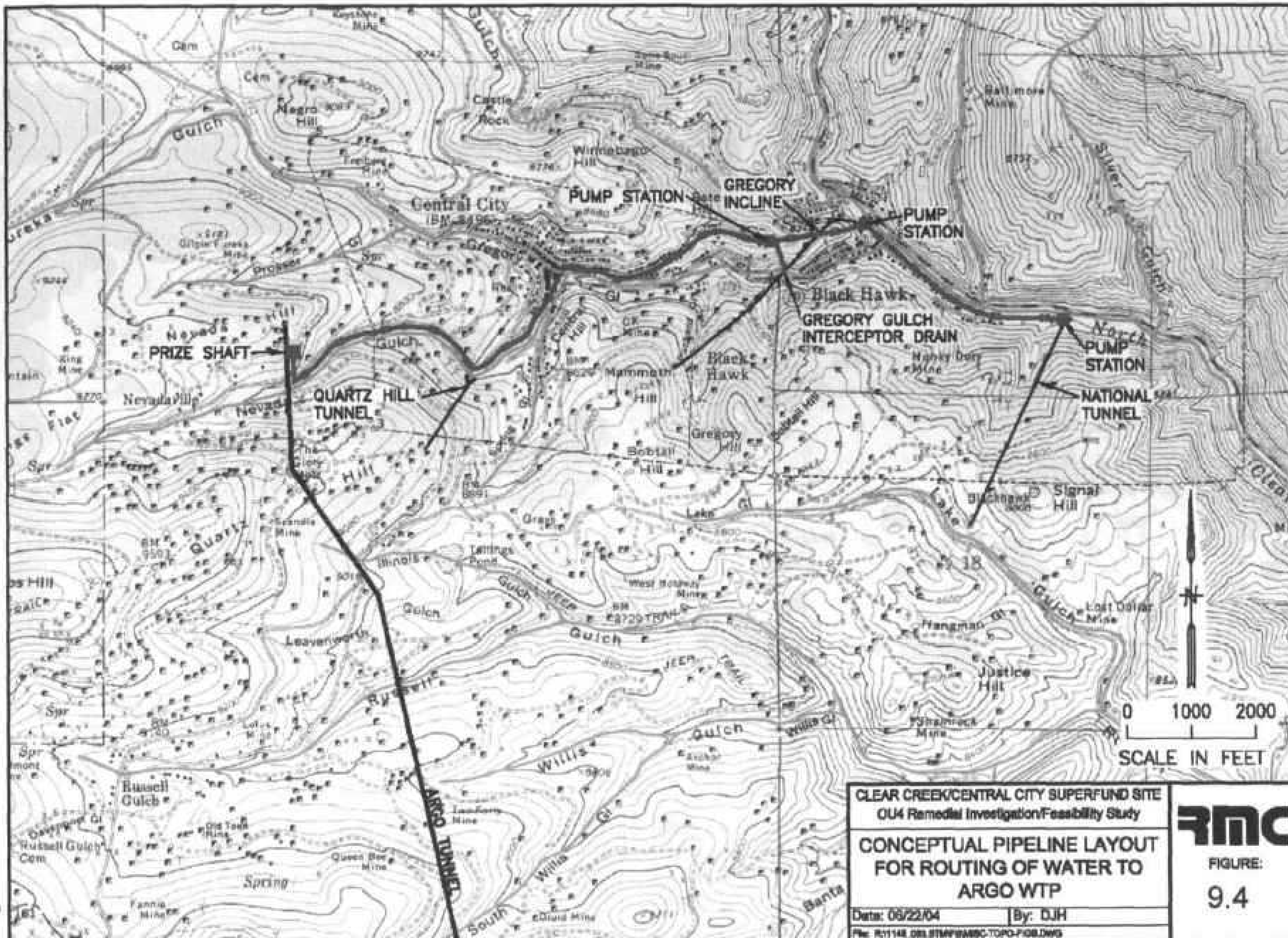


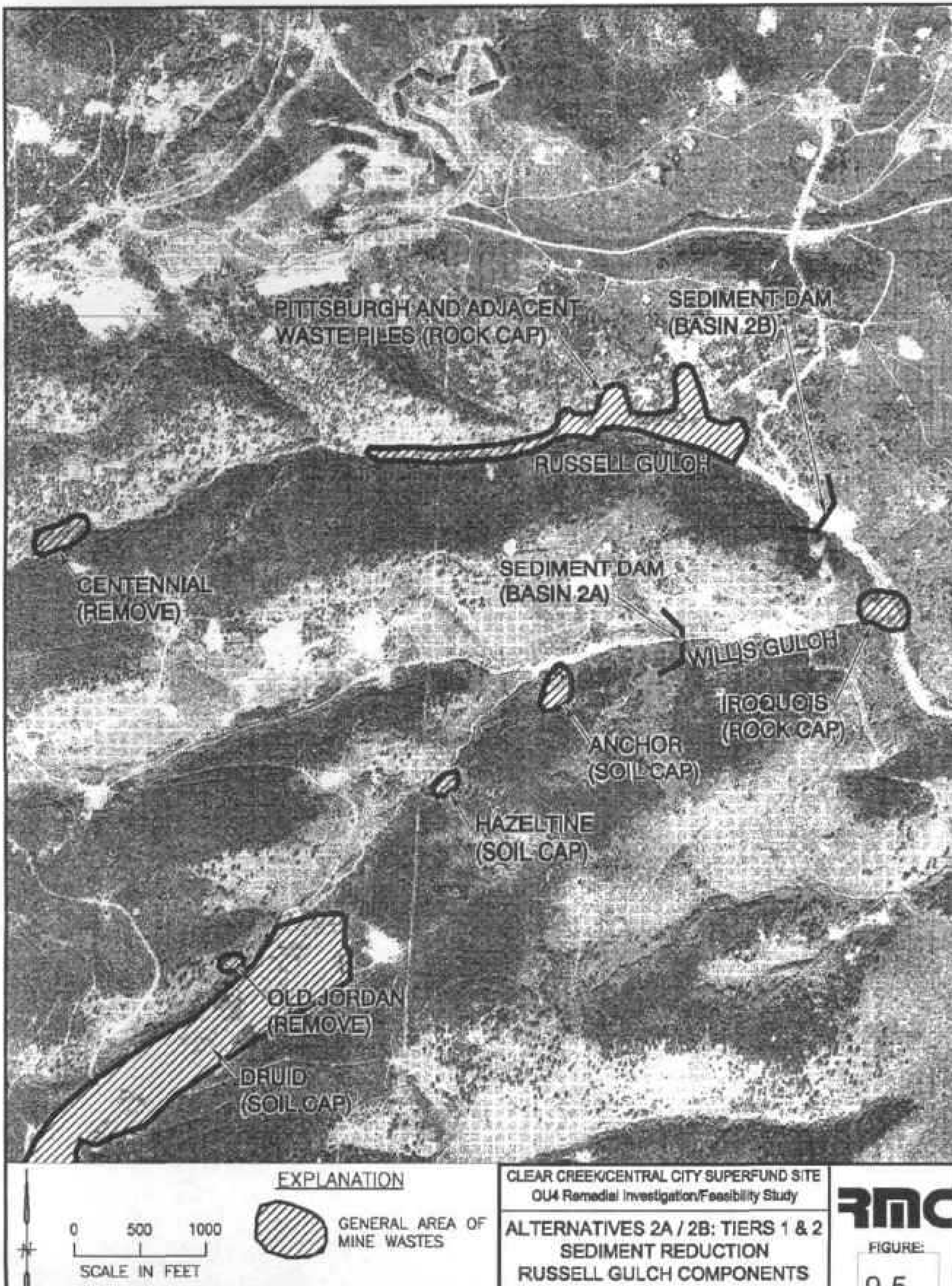
CLEAR CREEK/CENTRAL CITY SUPERFUND SITE
OU4 Remedial Investigation/Feasibility Study

CONCEPTUAL PIPELINE LAYOUT FOR ROUTING OF WATER TO ARGO WTP

RMC

FIGURE: 9.4

Date: 06/22/04 | By: DJH



NOTE: REMOVAL OF THE NIAGRA WASTE PILE AND SEDIMENT DAM ON BASIN 2 ARE NOT SHOWN ON THIS FIGURE.

CLEAR CREEK/CENTRAL CITY SUPERFUND SITE
OU4 Remedial Investigation/Feasibility Study

ALTERNATIVES 2A / 2B: TIERS 1 & 2
SEDIMENT REDUCTION
RUSSELL GULCH COMPONENTS

Date: 05/11/04 By: DJH

RMC

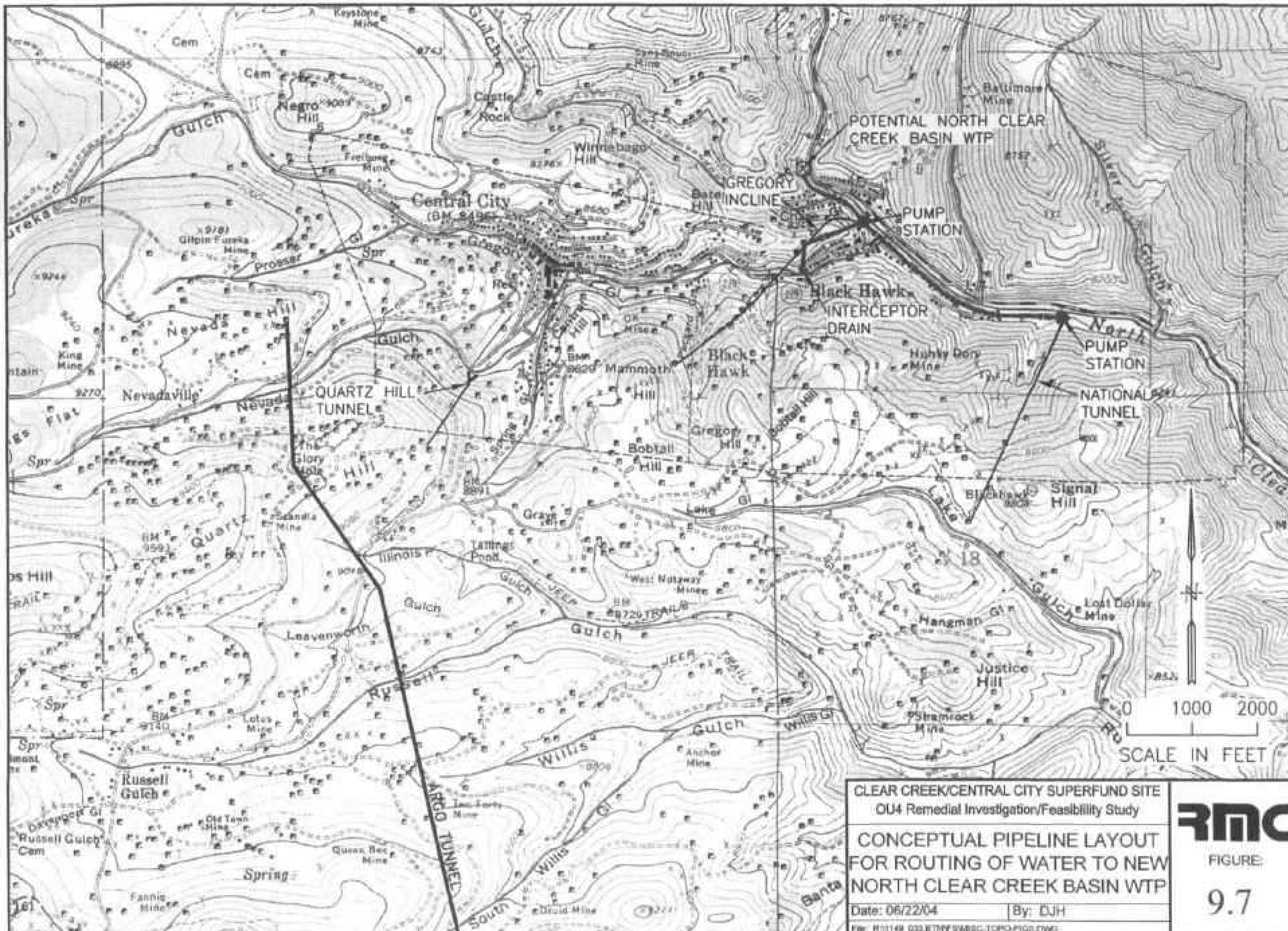
FIGURE: 9.5

CLEAR CREEK/CENTRAL CITY SUPERFUND SITE
OU4 Remedial Investigation/Feasibility Study

ALTERNATIVES 2A/2B: TIERS 1 AND 2 SEDIMENT REDUCTION NEVADA GULCH COMPONENTS

Date: 05/11/04 | By: DJH

FIGURE: 9.6



CLEAR CREEK/CENTRAL CITY SUPERFUND SITE
OU4 Remedial Investigation/Feasibility Study

CONCEPTUAL PIPELINE LAYOUT FOR ROUTING OF WATER TO NEW NORTH CLEAR CREEK BASIN WTP

Date: 06/22/04 | By: DJH

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RMC

FIGURE: 9.7

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Appendix B

Tables for the Record of Decision

TABLE 9.1

SUMMARY OF PRELIMINARY ALTERNATIVES REVIEW AND DEVELOPMENT REPORT
EVALUATION OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Cost	Retained for Development of Alternatives
No Action	None	Not applicable	Does not meet remedial action objectives	Readily implemented	Negligible to very low	Yes
Institutional Controls/Actions	Governmental Controls	Zoning, Ordinances, Permits	Depends on future continuation of controls; does not reduce contamination	Legal requirements and authority	Negligible to very low	Yes
	Proprietary Controls	Easements and Covenants	Depends on future continuation of controls; does not reduce contamination	Legal requirements	Negligible to very low	Yes
	Enforcement Tools	Administrative Orders and Consent Decrees	Depends on future continuation of controls; does not reduce contamination	Legal requirements and authority	Negligible to very low	Yes
	Informational Devices	State Registries, Deed Notices, Advisories	Depends on future continuation of devices; does not reduce contamination	Minimal regulatory requirements	Negligible to very low	Yes
	Alternate Water Supply	Connect to City Water; Provide Bottled Water	Prevents use of contaminated groundwater; no contaminant reduction	Moderate to difficult implementability; requires local approval	High capital due to terrain; low O&M	Yes
	Monitoring	Groundwater/Surface Water monitoring	Useful to document conditions; does not reduce contamination	Readily implemented	Low capital and maintenance	Yes
Treatment	Physical	Physical Separation	Reduces contaminant volume, but not toxicity or mobility; sorbed metals can't be separated	Readily implemented with commercially available equipment	Medium capital; high O&M	No
		Ion Exchange	Reduces volume of most metals, but not toxicity or mobility; follow-up treatment needed	Moderate implementability with commercially available equipment	High capital and O&M	No
		Electrokinetics	Reduces volume of most metals, but not toxicity or mobility; follow-up treatment needed. Each application only treats small area.	Moderate implementability; requires direct electrical current	Medium capital and O&M	No
		Micro Filtration	Effective in reducing contaminant volume, mobility, and toxicity; requires sludge disposal	Moderate implementability with commercially available equipment	High capital; medium O&M	Yes
	Chemical	On-Site Precipitation	Reliable in reducing contaminant volume, mobility, and toxicity; requires sludge disposal	Moderate implementability with commercially available equipment	High capital; medium to high O&M	Yes
		Offsite Treatment	Effective in reducing contaminant volume	Moderate to difficult implementability; requires hauling or piping followed by treatment	Medium to high capital and O&M	Yes
		Ex-Situ Soil Washing	Reduces volume of most metals, but not toxicity or mobility; follow-up treatment needed	Moderate implementability with commercially available equipment	Medium to high capital and O&M	No
		In-Situ Soil Mixing	Effective to reduce contaminant mobility in short term	Readily to moderate implementability depending on soil properties	Medium capital and maintenance	Yes
		Encapsulation	Effective to reduce contaminant mobility in short term	Readily to moderate implementability	Medium capital and maintenance	Yes
		Subsurface Treatment	Unknown effectiveness due to unknown conditions of underground workings	Moderate to difficult implementability if information on workings is unknown	Med capital; maybe high maintenance	Yes

TABLE 9.1

SUMMARY OF PRELIMINARY ALTERNATIVES REVIEW AND DEVELOPMENT REPORT
EVALUATION OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Cost	Retained for Development of Alternatives
Collection, Diversion and Containment	Offsite Discharge	Offsite Stream	Effective discharge method but does not reduce contamination volume or mobility	Moderate to implement; maybe more difficult if water has to be conveyed long distances	Medium to high capital and O&M	No
	On-Site Discharge	Local Stream	Effective discharge method but does not reduce contaminant volume or mobility	Moderate implementability	Low to medium capital and O&M	Yes
	Subsurface Controls	Trenches/Drains	Effective in reducing contaminant mobility in low permeable materials	Moderate implementability in porous media; difficult in fractured media	Med to high capital; low maintenance	Yes
		Storage of Water	Effective in reducing contaminant mobility; some contaminant attenuation is possible	Moderate to implement; maybe more difficult if rehabilitation of adits/tunnels is required	Medium to high capital; low maintenance	Yes
	Surface Water Controls	Run On Ditches	Effective in reducing contaminant volume	Readily implemented; moderate in steep terrains	Low to medium capital and maintenance	Yes
		Run-Off Ditches	Effective in reducing contaminant mobility	Readily implemented; moderate in steep terrains	Low to medium capital and maintenance	Yes
		Diversion Channels	Effective in separating contaminated and non-contaminated water	Moderate implementability	Medium capital and maintenance	Yes
		Impoundments	Effective in reducing contaminant mobility for subsequent management or treatment	Moderate implementability; depends on size	Med. to high capital; med. maintenance	Yes
		Settling Basins	Effective in reducing contaminant mobility in water or sediments	Moderate implementability; depends on size	Med. to high capital; med. maintenance	Yes
		Channel Stabilization	Effective in reducing contaminated sediment transport	Readily to moderate implementability	Low to med capital; low maintenance	Yes
	Surface Controls	Grading	Reduces erosional transport of contaminants	Readily implemented	Low capital and maintenance	Yes
		Revegetation	Reduces erosional transport of contaminants and infiltration	Readily implemented	Low capital and maintenance	Yes
		Simple Cover	Reduces erosional transport of contaminants and infiltration	Readily implemented	Low capital and maintenance	Yes
		Capping	Reliable in reducing contaminant mobility and infiltration, and erosional transport	Moderate implementability; more difficult if multi-layer geosynthetic liners are used	Med to high capital; low to med. maint.	Yes
		Chemical Application	Effective for short term reduction in contaminant mobility	Readily implemented; moderate in steep terrains	Low to med. capital and maintenance	Yes
		Physical Stabilization	Reduces erosional transport of contaminants and infiltration	Readily implemented; moderate in steep terrains	Low to med. capital and maintenance	Yes
	Barriers	Slurry Walls	Effective in reducing contaminant mobility in porous media, not effective in bedrock	Readily implemented at shallow depths; moderate for deeper walls	Medium capital and low maintenance	Yes
		Grouting	Effective in reducing contaminant mobility in fractured bedrock	Readily implemented if bedrock is at surface; moderate in underground working	Medium capital and low maintenance	Yes
		Sheet Piling	Reduces contaminant mobility in groundwater; but joints may leak	Readily implemented in fine-grain material; difficult in coarse-grained material	Low to med. capital; low maintenance	Yes
		Retaining Structures	Effective in reducing stability and erosional transport	Readily implemented; moderate in steep terrains	Low to med. capital; low maintenance	Yes
		Sediment Dams/Traps	Effective in reducing sediment transport and contaminant mobility; requires mucking	Readily implemented for traps; moderate for dams depending on size	Low to med. capital and maintenance	Yes

TABLE 9.1

SUMMARY OF PRELIMINARY ALTERNATIVES REVIEW AND DEVELOPMENT REPORT EVALUATION OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Cost	Retained for Development of Alternatives
Removal, Transport and Disposal	Removal	Excavation	Effective means to reduce volume and mobility of contaminated solid material	Readily implemented	Low to med capital; no maintenance	Yes
	Transport	Truck Hauling	Effective means to transport contaminated solid material	Readily implemented; dependent on hauling distance	Low to high capital; no maintenance	Yes
		Slurrying	Not effective because contaminated solids would contaminate slurry water	Moderate to difficult to implement; dependent on distance	Medium to high capital and O&M	No
		Pipeline	Effective means to transport contaminated water	Moderate to implement; dependent on distance	Medium to high capital; low maint.	Yes
	Disposal	On-Site Landfill	Effective means to store contaminated solid material and reduce contaminant mobility	Moderate; difficult for new construction; dependent on lining and leachate collection	Medium to high capital and O&M	Yes
		Offsite Landfill	Effective means to store contaminated solid material and reduce contaminant mobility	Moderate to implement assuming landfill already exists; dependent on distance to landfill	Med to high capital	Yes
		Underground	Effectiveness is unknown	Moderate to difficult to implement; dependent on knowing volume and location of workings	Med. to high capital; low maintenance	No
		Consolidation	Effective to reduce contaminant mobility	Moderate to implement; dependent on terrain and volume of material	Medium to high capital; low maint.	Yes
Innovative and Emerging Technologies	Permeable Reactive Barriers		Potentially effective to reduce mobility and volume of contaminated groundwater	Readily implemented in unconsolidated material; difficult in bedrock or in urban setting	Low to med. capital; low maintenance	Yes
	Biological Treatment (Bioremediation), including Constructed Wetlands		Potentially effective to reduce mobility and volume at low flow rates	Readily implemented; difficult in steep terrain; requires land for treatment cells	Low to med. capital; low maintenance	Yes

Note: Evaluations based on technical publications U.S. EPA (2000b), Evanko and Dzombak (1997), and engineering /professional judgment

No = Technologies judged to be ineffective, difficult to implement, or to have high costs.

TABLE 9.2

RANKING OF DRAINAGES FOR POTENTIAL CONTAMINATION FROM WASTE ROCK OR TAILINGS PILES

Drainage	*Notable Mines/Waste Piles within Drainage*	*Overall Ranking*	*Potential to Produce Contamination*	
Lower Nevada Gulch	Quartz Hill	1	High	↑ Highest Potential
Upper Nevada Gulch	Several mines near Nevadaville	2	High	
South Willis Gulch	Druid	3	High	
Middle Russell Gulch	Aurora, Pittsburgh, Notaway, Iriquois	4	High	
Upper Russell Gulch	Old Town, Pewabic, Iron Duke, Gettysburg, Lotus	5	High	
Gregory Gulch	Gregory Gulch #3	6	Moderately High	
Illinois/Leavenworth Gulch	Calhoon, Jupiter, Chain of Mines, tailings ponds on Illinois Gulch	7	Moderately High	
Main Stem North Clear Creek	North ½ of Golden Gilpin, East Williams, Dredge Tailings	8	Moderate	
Willis Gulch	Saratoga, Anchor, Silver Dollar, Chase	9	Moderate	
Lower Chase Gulch	Chase Gulch #2	10	Moderate	
Eureka Gulch	Freiburg	11	Moderate	
Prosser Gulch	Gilpin Eureka, King	12	Low	
Lake Gulch	Lost Dollar	13	Low	
Spring Gulch	NA	14	Low	
Elkhorn Gulch/Pleasant Valley	Sun, Moon, Arizona, Burtha, Moose	15	Low	
Pine Creek	NA	16	Low	Lowest Potential ↓
Lower Russell Gulch	No mines present	17	Low	

Notes:
NA = Names of mines not available

TABLE 10.1
SUMMARY OF ALTERNATIVE COMPONENTS AND COMPARATIVE ANALYSIS

COMPONENT DESCRIPTION	Alternative 1A No Action	Alternative 1B Institutional Controls	Alternative 2A Tier 1 Sediment Reduction	Alternative 2B Tier 2 Sediment Reduction/ Passive Treatment	Alternative 3A Active Water Treatment at Argo WTP with Tier 1 Sediment Reduction	Alternative 3B Active Water Treatment at New NCC WTP with Tier 1 Sediment Reduction	Alternative 3C Active Water Treatment at Argo WTP with Tier 2 Sediment Reduction	Alternative 4A Passive Water Treatment with Tier 1 Sediment Reduction	Alternative 4B Combined Passive and Active Water Treatment with Tier 2 Sediment Reduction
ADMINISTRATIVE ACTIONS									
Issuance of UAOs and AOCs		X							
Granting of Environmental Covenants		X							
Installation of Fencing and Signs		X							
REMEDIAL ACTIONS/CAPITAL EXPENDITURES									
Tributary Sediment Reduction									
Mine Waste Pile Removal: Hazra, Centennial, Old Jordan, and Gregory Gulch No. 3			X	X	X	X	X	X	X
Mine Waste Pile Capping (Rock): Argo, Pittsburgh, Mattie May, Baltimore, Iroquois, and Upper Nevada Gulch (North Side)			X	X	X	X	X	X	X
Mine Waste Pile Capping (Soil) and Revegetate: Anchor, Druid, Hazeltine, and Upper Nevada Gulch (South Side)			X	X	X	X	X	X	X
Channel Stabilization of Channels Adjacent to Capped/Removed Waste Piles			X	X	X	X	X	X	X
Construction of Run-On Ditches Upslope of Argo, Anchor, Druid, Hazeltine, Iroquois, Pittsburgh, Mattie May, Baltimore, and Upper Nevada Gulch Waste Piles			X	X	X	X	X	X	X
Sediment Dam Construction: Willis Gulch (Basin 2A), Russell Gulch (Basins 2 & 2B) and Upper Nevada Gulch (Basin 1)			X	X	X	X	X	X	X
North Clear Creek Sediment Reduction/Passive Water Treatment									
Remove Mine Waste from Channel and Riparian Zone				X			X		
Reconstruct Channel with Riffle-Pool Complex				X			X		
Reconstruct Bankfull Channel with Sinuosity				X			X		
Stabilize Channel with Deformable Banks, Stone Toe Protection, Rootwads, J-Hooks				X			X		
Revegetate Riparian Zone				X			X		
In-Stream Grade Control Structures				X			X		
In-Stream Free Water Surface (FWS) Cells				X			X		
Point Source Contaminated Water Capture, Conveyance and Treatment									
Construction of Pump Station/Pipeline from National Tunnel to Gregory Incline					X	X	X		
Construction of Pump Stations/Pipeline from Gregory Incline to Prize Shaft					X		X		
Construction of Gregory Gulch Alluvial Groundwater Interceptor Drain and Sump					X	X	X	X	X
Construction of Pipeline from Gregory Gulch Groundwater Interceptor Drain Sump to Prize Shaft Pipeline					X		X		
Re-open Prize Shaft					X		X		
Upgrades/Improvements to Argo Water Treatment Plant					X		X		
Construction of Pipeline from Gregory Gulch Groundwater Interceptor Drain Sump to Gregory Incline						X		X	
Construction of Pump Station/Pipeline from Gregory Incline to Active New Water Treatment Plant						X			
Construction of New Active Water Treatment Plant						X			
Construction of Gravity Flow Pipeline from Gregory Incline, Connecting to Existing National Tunnel Pipeline, to Passive Water Treatment System								X	
Construction of Full Size Passive Water Treatment System								X	
Construction of Pump Stations/Pipeline from Gregory Incline to Gregory Gulch Drain Sump									X
Construction of Pump Station/Pipeline from Gregory Gulch Drain Sump to Bates Hunter Active Water Treatment Plant									X
Construction of Gravity Flow Pipeline from Existing National Tunnel Pipeline to Passive Water Treatment System									X
Construction of Small Scale Passive Water Treatment System									X
OPERATION AND MAINTENANCE/PERIODIC ITEMS									
Annual Exterior Inspection of the Existing Gregory Incline and the National Tunnel Pipelines	X	X	X	X					
Cleaning of the Existing Gregory Incline and National Tunnel Pipelines every Five Years	X	X	X	X					
Annual Inspection and Routine Maintenance of Existing Waste Pile Caps and Stabilized Channels	X	X	X	X	X	X	X	X	X
High- and Low- Flow Sampling of North Clear Creek and Main Stem Clear Creek Every Other Year		X	X	X	X	X	X	X	X
Maintenance of Access Roads			X	X	X	X	X	X	X
Revegetation/Maintain Ditches			X	X	X	X	X	X	X
Sediment Disposal in Onsite Mine Waste Repository			X	X	X	X	X	X	X
Additional Argo Water Treatment Plant O&M					X		X		
North Clear Creek Basin Active Water Treatment Plant O&M						X			X
North Clear Creek Basin Passive Water Treatment System O&M								X	X
POTENTIAL ADDITIONAL REMEDIAL ACTIONS									
Argo Tunnel Flow-Through Plug			X	X	X	X	X	X	X
Passive Treatment of Quartz Hill Tunnel Discharge			X	X					
Piping of Quartz Hill Tunnel Discharge to a Mineshaft for Conveyance to the Argo WTP			X	X					
North Clear Creek Energy Dissipation Structures			X	X	X	X	X	X	X
Black Hawk Groundwater Interceptor System					X	X	X	X	X
Lake Gulch Lining			X	X	X	X	X	X	X
Gregory Gulch Lining			X	X	X	X	X	X	X
Black Hawk Groundwater Permeable Reactive Barrier			X	X	X	X	X	X	X
COMPARATIVE ANALYSIS[1]									
Protection of Human Health and Environment	9	8	7	6	3	3	1	5	2
Compliance with ARARs	9	8	7	6	3	3	1	5	2
Long-Term Effectiveness and Permanence	9	8	7	6	3	1	2	5	4
Reduction of Toxicity, Mobility, or Volume	8	8	7	6	3	2	1	5	4
Short-Term Effectiveness	9	8	7	6	4	2	3	5	1
Implementability	1	2	3	4	7	5	8	6	9
Cost	1	2	3	5	6	9	8	4	7

[1]ranked from highest to lowest ability to fulfill the criteria (1 being the highest, 9 being the lowest). Equivalent rankings given the same score. In terms of implementability, 1 is the easiest to implement, 9 is the most difficult

TABLE 10.2
CHEMICAL-SPECIFIC ARARS

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate	Comments
FEDERAL				
Clean Water Act Federal Water Quality Criteria	40 CFR Part 131 Quality Criteria for Water, 1986, pursuant to 33 USC § 1314	Sets standards for surface water to protect aquatic life and human health.	Applicable	
National Primary Drinking Water Regulations (MCLs)	40 CFR Part 141, Subpart B pursuant to 42 USC §§ 300g-1 and 300j-9	Regulates drinking water quality.	Relevant and Appropriate	New Arsenic Standard is TBC until 2006 effective date, after which it will be Relevant and Appropriate
National Secondary Drinking Water Regulations (SMCLs)	40 CFR Part 143, pursuant to 42 USC §§ 300g-1(c) and 300j-9	Sets standards for drinking water based on health and aesthetics.	Relevant and Appropriate	
Federal Total Maximum Daily Loads (TMDLs)	Clean Water Act 33 USC 1313; 40 CFR Part 130.7	Requires states to identify impaired waters and to establish total maximum daily loads to ensure that water quality standards can be attained; possible TBC.	No	Potential TBC. The WQCD has not completed a TMDL for North Clear Creek Segment 13b or Clear Creek Segment 11.
Clean Air Act, National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50, pursuant to 42 USC § 7409	Sets standards for air emissions.	No	Anticipated remedial actions do not include source categories covered by the regulations.
National Emission Standards for Hazardous Air Pollutants	40 CFR Part 61, Subparts N, O, P, pursuant to 42 USC § 7412	Regulates emission of hazardous chemicals to the atmosphere.	No	Regulated constituents not present at site. If they are found to occur at regulated levels, these regulations would be applicable.
Toxic Substances Control Act, PCB Spill Cleanup Policy	52 FR 10688 April 2, 1987	Regulates hazardous materials from manufacture to disposal.	No	Regulated constituents not present at site
Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites	EPA Directive #9355.4-12, July 1994	Suggests levels for lead in soil.	No	TBC
EPA Sediment Toxicity Guidelines	EPA 905/R-00/007, June 2000	Prediction of sediment toxicity using consensus-based freshwater sediment quality guidelines.	No	TBC
RCRA Subtitle C Groundwater Protection Standards	40 CFR 264.92-264.101	Sets standards for groundwater at RCRA facilities.	No	The remedial action does not address RCRA wastes because there are no known RCRA wastes at the site.

TABLE 10.2
CHEMICAL-SPECIFIC ARARS

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate	Comments
STATE				
Colorado Primary Drinking Water Standards	5 CCR 1003-1	Establishes health-based standards for public water systems.	Relevant and Appropriate	Clear Creek classified for water supply use.
Basic Standards and Methodologies for Surface Water: WQCD Reg. No. 31	5 CCR 1002-31	Provides basic standards, antidegradation rule, implementation process, and system for classifying surface water, assigning water quality standards and review of classifications and standards, as determined by the Colorado WQCC.	Applicable	
Colorado Classification and Numeric Standards for South Platte River Basin: WQCD Reg. No. 38	5 CCR 1002-38	Classification and numeric standards for the South Platte River Basin, including tributaries and standing bodies of water. Classification identifies actual beneficial uses of water and allowable concentrations of various parameters.	Applicable	
Basic Standards for Groundwater: WQCD Reg. No. 41	5 CCR 1002-41	Sets standards for contaminants in groundwater.	Applicable	
Colorado Air Pollution Prevention and Control Act, CRS § 25-7-101 et. seq.	5 CCR 1001	Sets standards for air emissions.	Potentially Applicable	Anticipated remedial actions do not include source categories covered by the regulations.
Colorado Emission Standards for Hazardous Air Pollutants	CRS § 25-7-108, 5 CCR 1001-10, Reg. 8	Regulates emission of hazardous chemicals to the atmosphere.	No	Regulated constituents not present at site. If they are found to occur at regulated levels, these regulations would become applicable.
Proposed Soil Remediation Objectives Policy Document	CDPHE HMWMD, December 31, 1997	Proposes guidance in establishing soil cleanup standards.	No	TBC
Provisional Implementation Guidance for Determining Sediment Deposition Impacts to Aquatic Life in Streams and Rivers	Colorado Water Quality Control Commission Policy 98-1, June 1998, revised May 2002	Guidance for assessing impacts to aquatic life and habitat conditions caused by human induced erosion and deposition of materials in aquatic systems.	No	TBC

TABLE 10.3
LOCATION-SPECIFIC ARARS

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate	Comments
FEDERAL				
National Historic Preservation Act	16 USC § 470 et seq. A portion of 40 CFR § 6.301 (b), 30 CFR Part 63, Part 65, Part 800	Regulates impacts to historic places and structures.	Applicable	
The Historic and Archaeological Data Preservation Act of 1974	16 USC 469 40 CFR § 6.301(c)	Protects sites with archeological significance.	Applicable	
Historic Sites Act of 1935, Executive Order 11593	16 USC §§ 461 et.seq. 40 CFR § 6.301(a)	Regulates designation and protection of historic places.	Applicable	
The Archaeological Resources Protection Act of 1979	16 USC §§ 470aa-47011	Regulates removal of archeological resources from public or tribal lands.	Applicable	
Executive Order No. 11990 Protection of Wetlands	40 CFR § 6.302(a) and Appendix A	Minimizes impacts to wetlands.	Applicable	
Executive Order No. 11988 Floodplain Management	40 CFR § 6.302 and Appendix A	Regulates construction in floodplains.	Applicable	
Wild and Scenic Rivers Act	16 USC §§ 1271-1287 40 CFR § 6.302(e) 36 CFR Part 297	Establishes requirements to protect wild, scenic, or recreational rivers.	No	No regulated rivers impacted
Wilderness Act	16 USC 1311, 16 USC 668 50 CFR 53, 50 CFR 27	Limits activities within areas designated as wilderness or National Wildlife Refuge.	No	Area not a designated wilderness
Fish and Wildlife Coordination Act	16 USC § 661 et seq. 40 CFR § 6.302(g)	Requires coordination with Federal and State agencies to provide protection of fish and wildlife.	Applicable	
Endangered Species Act	16 USC §§ 1531-1543 50 CFR Parts 17, 402 40 CFR § 6.302(b)	Regulates the protection of threatened or endangered species.	Applicable	Only if threatened and endangered species or their habitats are identified

TABLE 10.3
LOCATION-SPECIFIC ARARS

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate	Comments
FEDERAL				
Migratory Bird Treaty Act	16 USC § 703-12	The act contains a requirement for agencies to examine proposed actions by the government relative to habitat impacts and impacts to individual organisms.	Applicable	
Executive Order No. 12962 Recreational Fisheries	16 USC § 742a-d and e-j; 16 USC § 661-666c; 42 USC § 4321; and 16USC § 1801-1882	The order contains a requirement that Federal agencies, to the extent permitted by law and where practicable and in cooperation with State and Tribes, improve the quantity, function, sustainable productivity, and distribution of U.S. aquatic resources for increased recreational fishing opportunities.	Applicable	
STATE				
Historic Places Register	CRS §§ 24-80.1-101 to 108	The State historic preservation officer reviews potential impacts to historic places and structures.	Applicable	
Colorado Natural Areas	Colorado Revised Statutes, Title 33 Article 33, Section 104	Maintains a list of plant species of "special concern." Recommends coordination among Division of Parks and Outdoor Recreation.	Applicable	Only if appropriate plant species are present
Colorado Species of Special Concern and Species of Undetermined Status	Colorado Division of Wildlife Administrative Directive E-1, 1985, modified	Protects species listed on the Colorado Division of Wildlife generated list.	Applicable	Only if appropriate wildlife species are present
Wildlife Commission Regulations	2 CCR 405-0	Establishes specific requirements for protection of wildlife.	Applicable	
Non-game, Endangered, or Threatened Species Act	CRS §§ 33-2-101 to 108	Standards for regulation of non-game wildlife and threatened and endangered species.	Applicable	Only if appropriate species are present

TABLE 10.4
ACTION-SPECIFIC ARARS

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate	Comments
FEDERAL				
Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act of 1976 (RCRA Subtitle D)	40 CFR Part 257, Subpart A: § 257.3-1 Floodplains, paragraph (a); § 257.3-7 Air, paragraph (b)	Regulates the generation, storage, handling and disposal of solid waste.	On-Site: Applicable or Relevant and Appropriate Offsite: Applicable	Relevant and appropriate to in-place capping. Applicable to on-site consolidation or off-site disposal.
RCRA Subtitle C	40 CFR Part 261.4(b)(7) and RCRA Section 3001(b) (Beville Amendment)	Regulates the generation, treatment, storage and disposal of hazardous wastes. Applicable for disposal of listed wastes.	Potentially Relevant and Appropriate	No known RCRA wastes at site. Relevant and appropriate to sludges generated at a water treatment plant, if the sludges fail TCLP.
Standards Applicable to Generation of Hazardous Waste	40 CFR Part 262, pursuant to 42 USC § 6922	Establishes standards for the generation of hazardous waste.	See RCRA Subtitle C	
Standards Applicable to Transporters of Hazardous Waste	40 CFR Part 263, pursuant to 42 USC § 6823	Regulates the transportation of hazardous waste.	See RCRA Subtitle C	
Hazardous Materials Transportation Act, D.O.T. Hazardous Materials Transportation Regulations	49 USC §§ 1801-1813 49 CFR Parts 107, 171-177	Regulates the transportation of hazardous materials.	See RCRA Subtitle C	
Dredge and Fill Requirements	40 CFR 230-233, 320-330, Section 404, pursuant to 33 USC § 1251-1376	Prohibits discharge of dredged of fill material into wetlands or navigable waters of the U.S. without permit.	Applicable	
Underground Storage Tanks	40 CFR Part 280	Establishes regulations for the monitoring, design, and construction of underground storage tanks.	No	Not present at site
Underground Injection Control Regulations	40 CFR §§ 144.12, 144.24, and 144.25, pursuant to 42 USC § 123(e)(1)	Establishes requirements for injection of waste water into wells and aquifers.	Applicable	Would apply if injecting to a mine shaft or mine workings is used as disposal. Not applicable if the mine workings are a means of conveyance and not disposal.
National Pollutant Discharge Elimination System (NPDES)	40 CFR Parts 122, 125, pursuant to 33 USC § 1342	Regulates the discharge of pollutants to waters of the U.S.	Applicable	Would apply to point source discharges

TABLE 10.4
ACTION-SPECIFIC ARARS

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate	Comments
STATE				
Colorado Solid Waste Disposal Sites and Facilities Act	6 CCR 1007-2, pursuant to CRS § 30-20-101, et.seq.	Establishes standards for the licensing, locating, constructing, and operating solid waste facilities.	On-Site: Applicable or Relevant and Appropriate Offsite: Applicable	Relevant and appropriate to in-place capping. Applicable to on-site consolidation or off-site disposal.
Colorado Hazardous Waste Regulations	6 CCR 1007-3	Regulates the siting, construction, operation, and maintenance of hazardous waste disposal facilities.	Potentially Relevant and Appropriate	Relevant and appropriate if sludges generated at a water treatment plant fail TCLP.
Colorado Mined Land Reclamation Act	CRS 34-32-101 to 125 Rule 3 of Mineral Rules and Regulations	Regulates all aspects of mining, including reclamation plans and socioeconomic impacts.	Relevant and Appropriate	
Colorado Discharge Permit System	5 CCR 1002-61	Implementation of the Colorado Water Quality Control Act, and applies to operations discharging to waters of the state from a point source.	Applicable	Would apply to point source discharges
Colorado Water Quality Control Act. Storm Water Discharge Regulations	5 CCR 1002-61	Regulates discharge of storm water during construction activities.	Applicable	
Protection of Fishing Streams	CRS 33-5-101 - 107	Establishes notification requirements for modifications to streams.	No	Fish are currently not present in Segment 3b of North Clear Creek
Reservoirs and Rules and Regulations for Dam Safety and Dam Construction	CRS 37-87-101 - 125, 37-80-(11k), and 24-4-103	Establishes rules and regulations for the design, construction, and operation of dams and reservoirs.	No	Independently applicable
Colorado Air Pollution Prevention and Control Act	5 CCR 1001-3; Section III.D; Reg. 1	Regulates fugitive emissions during construction.	Relevant and Appropriate	Contemplated actions would not trigger permit requirements, however dust control will be required.
Colorado Air Pollution Prevention and Control Act	5 CCR 1001-5, Regulation 3 APENs	Establishes requirements for obtaining permits.	No	Contemplated actions would not trigger permit requirements
Colorado Air Pollution Prevention and Control Act	5 CCR 1001-4, Regulation 2 Odors, Part A	Regulates generation of odors.	Applicable	Applicable to passive treatment system. No other remedial actions generate odors.
Colorado Noise Abatement Statute	CRS §§ 25-12-101, eq.seq.	Establishes standards for controlling noise.	Applicable	In areas zoned residential, commercial or industrial

TABLE 10.4
ACTION-SPECIFIC ARARS

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable <u>or</u> Relevant and Appropriate	Comments
Colorado Environmental Real Covenants Act	CRS § 25-15-317 to 327	Requires environmental covenant whenever environmental remediation project results in less than unrestricted land use or uses an engineered structure or feature that requires monitoring, maintenance or operation to function or that will not function as intended if disturbed.	Applicable	

TABLE 10.5
COST SUMMARY OF REMEDIAL ALTERNATIVES FOR OU4

	Costs			
Cleanup Alternative	**Capital**	**Present Value of 30 years of O&M Costs**	**Total Present Value of Alternative**	**Equivalent Yearly O&M Costs**
1A: No Action	$0	$177,000	$177,000	$14,000
1B: Institutional Controls	$229,000	$521,000	$750,000	$42,000
2A: Tier 1 (tributary) sediment reduction	$5,321,000	$1,286,000	$6,607,000	$104,000
2B: Tier 2 (tributary and North Fork main stem) sediment reduction	$11,570,000	$1,434,000	$13,004,000	$116,000
3A: Water treatment at Argo WTP with Tier 1 sediment reduction	$11,591,000	$7,892,000	$19,483,000	$636,000
3B: Water treatment at new North Fork WTP with Tier 1 sediment reduction	$17,761,000	$14,420,000	$32,181,000	$1,162,000
3C: Water Treatment at Argo WTP with Tier 2 Sediment Reduction	$17,017,000	$8,140,000	$25,157,000	$656,000
4A: Water treatment at North Fork Passive Treatment system with Tier 1 sediment reduction	$7,554,000	$2,725,000	$10,279,000	$220,000
4B: Combined water treatment using Passive Treatment and Bates-Hunter WTP with Tier 2 sediment reduction	$11,833,000	$11,496,000	$23,329,000	$926,000

TABLE 12.1
DETAILED COST ESTIMATE FOR ALTERNATIVE 4B

Capital Costs		
Tributary Sediment Improvements (Tier 1)		
Sediment Detention Structures	$	748,000
Waste Pile Removal and Capping	$	2,185,000
Channel Stabilization and Run-On Ditches	$	1,107,000
Subtotal Tier 1 Sediment	**$**	**4,040,000**
North Clear Creek Sediment Improvements (additional items for Tier 2)		
NCC FWSs & Channel Riparian Reconstruction	$	4,297,000
Hydraulic Structures, Waste Removal & Revegetation	$	398,000
Subtotal Tier 2 Sediment	**$**	**4,695,000**
Water Treatment Aspects of Remediation		
National Tunnel Sulfate Reducing Bioreactor System	$	538,000
Water Treatment Plant Upgrades and Startup	$	410,000
Mine & Ground Water Collection & Piping	$	171,000
Pump Station, Electrical and Other Costs	$	259,000
Subtotal Water Treatment Components	**$**	**1,378,000**
Subtotal Remedy Construction	**$**	**10,113,000**
Project Management, Engineering, Design and Construction Management (appox 17%)	**$**	**1,720,000**
Total Capital Costs	**$11,833,000**	

TABLE 12.1 CONT.
DETAILED COST ESTIMATE FOR ALTERNATIVE 4B

Operation and Maintenance Costs

Sediment Improvements O&M and Sitewide Monitoring	Present Value 7%, 30 years	Equivalent Annual Cost
Revegetation	$ 26,000	$ 2,000
Maintain Roads & Ditches	$ 384,000	$ 31,000
Maintain Tributary Sediment Basins	$ 574,000	$ 46,000
NCC Improvements	$ 121,000	$ 10,000
Adit/Pipline Cleaning	$ 12,000	$ 1,000
Sitewide Monitoring	$ 144,000	$ 12,000
Inspections	$ 101,000	$ 7,000
Data updates, other	$ 67,000	$ 5,000
Subtotal	**$ 1,429,000**	**$ 114,000**
Water Treatment O&M		
Bates Hunter WTP & National Tunnel Operations	$ 9,949,000	$ 802,000
Monitoring	$ 29,000	$ 3,000
Periodic Equipment Replacement	$ 49,000	$ 4,000
Periodic National Substrate Replacement	$ 40,000	$ 3,000
Subtotal Water Treatment	**$ 10,067,000**	**$ 812,000**
Total Operation & Maintenance Costs	**$ 11,496,000**	**$ 926,000**
Total Present Value of Capital and O & M	**$ 23,329,000**	

Appendix C

Responsiveness Summary

This Appendix C contains the responses of the Colorado Department of Public Health and Environment (CDPHE), Hazardous Materials and Waste Management Division (HMWMD) and US Environmental Protection Agency Superfund Program (EPA) to comments received concerning the Operable Unit 4 Proposed Plan and Feasibility Study. This Appendix summarizes the comments received, and provides responses. The original comments are on file at the Site information repositories located at the Agencies, and are available for public review.

The official public comment period for the Feasibility Study and Proposed Plan extended from July 23, 2004 to August 23, 2004. An advertised public meeting was held in Central City at the Gilpin County Courthouse on August 11, 2004 to summarize the proposed plan and to hear comment on the Proposed Plan and Feasibility Study. The proceedings of this meeting were recorded by a stenographer and are also available for public review at the Site information repositories located at the CDPHE and EPA offices. The proposed plan was also presented at a meeting of the Gilpin County Commissioners on August 3, 2004.

A presentation regarding the Feasibility Study and proposed plan options was made to the Upper Clear Creek Watershed Association on June 10, 2004. Prior presentations were made to the Upper Clear Creek Watershed Association in August and November 2002 regarding the Remedial Investigation, and in Fall 2003 regarding the alternative modeling results and a presenting a preview of the Feasibility Study.

Several commenting parties specifically expressed support for the preferred clean up plan as submitted in the Proposed Plan (Alternative 4B). Commenters supporting the preferred alternative included the City of Golden, the Town of Empire, the City of Northglenn, Black Hawk and Central City Sanitation District, the Clear Creek Watershed Foundation, the Upper Clear Creek Watershed Association, the Colorado Division of Wildlife, a private individual, and Gilpin County. The membership represented by the Upper Clear Creek Watershed Association includes the Black Hawk/Central City Sanitation District, the Central Clear Creek Sanitation District, the City of Black Hawk, Central City, the City of Golden, the City of Idaho Springs, Clear Creek Ski Corporation, Gilpin County, the Henderson Mine (Phelps Dodge Corp), Jefferson County, Saint Mary's Glacier Water and Sanitation District, Clear Creek County, the Town of Silver Plume, the Town of Empire, Shwayder Camp, the Town of Georgetown, the Colorado Department of Transportation, Coors Brewing Company, Saddleback Ridge, and Mount Vernon Country Club Metro District.

CDPHE would like to thank all of the people who took the time to review and comment on the various documents that have been released for comment. CDPHE would especially like to thank the Upper Clear Creek Watershed Association, which, collectively and though efforts of many of its individual members, has participated in the Superfund process and provided invaluable input and comment to CDPHE and EPA which has had a great influence on the approach and content of the Remedial Investigation, Feasibility Study, Proposed Plan and Record of Decision.

SPECIFIC COMMENTS

COMMENT: A downstream water user noted their support for cooperative efforts that improve the water quality of Clear Creek. It was noted that Clear Creek is their drinking water source and a vital economic and recreational benefit to the community.

RESPONSE: Clear Creek and North Clear Creek are upstream of the Cities of Golden, Arvada, Westminster, Northglenn and Thornton which all use Clear Creek water as a drinking water source. The remedial action objectives for OU4 include the objective to "ensure that in-stream metals concentrations do not degrade drinking water supplies diverted from the main stem Clear Creek."

COMMENT: The Clear Creek Watershed Foundation suggested a stronger case be presented that remedial actions within the basin address concerns of public health, safety and welfare, rather than relying only on objectives of aquatic life.

RESPONSE: The remedial objectives contained in the Feasibility Study and the Record of Decision include aquatic life based objectives for Clear Creek and the North Fork of Clear Creek. In addition, objectives addressing downstream drinking water supplies and protection from potential human health exposures related to mine waste piles are included in the remedial action objectives. Improvements to the water quality of Clear Creek and the North Fork of Clear Creek will have the direct benefit of increased viability and protection of aquatic life within the streams, which will in turn facilitate habitat and riparian corridor improvements. The improvements will also provide source water improvements and protection to the drinking water source used by the Cities of Golden, Arvada, Westminster, Northglenn and Thornton. Because these cities take measures to treat and otherwise assure the water they supply to their customers is safe and of the highest quality possible, CDPHE and EPA have not proposed Superfund actions, past and current, be justified solely based on downstream water uses. The mine waste pile capping, channel stabilization and stream bank stabilization included in the selected remedy will also reduce the potential for slides and slope failures. CDPHE and EPA agree that improvement to water quality and actions to improve and protect water quality in Clear Creek have far reaching broad benefits to public health safety and welfare of many citizens that are sometimes not given the emphasis that aquatic life objectives receive because the benefits are perhaps more difficult to directly quantify. These benefits extend to increased recreational opportunities, and will also foster habitat, riparian corridor, and land use improvements.

COMMENT: The Clear Creek Watershed Foundation suggested that the first repository should be developed at the Gem/Franklin site, noting that they believe hauling sludge and other wastes into other environments for disposal is hazardous and wasteful.

RESPONSE: While not directly addressed by the OU 4 Record of Decision and Feasibility Study, the Agencies have been pursuing construction of a mine waste repository which could be used for disposing of mine waste pile material and water treatment plant sludges generated by local Superfund projects such as the Argo Tunnel treatment plant in Idaho Springs. The Agencies have proposed a repository to reduce cost and distance of travel for disposal of such materials, to maximize program efficiencies, and to facilitate a more efficient means of addressing mine wastes than hauling them to landfills located on the front range. The proposed repository would utilize the high pH base characteristic of the sludges to counteract and neutralize the acidic low pH characteristic of mine waste pile material. CDPHE and EPA have been pursuing constructing a repository at the Druid site, the location of the former Solution Gold operation. The Agencies have not obtained the necessary property rights or been able to secure an appropriate agreement with the owner of the Druid site to proceed with the repository at that location. CDPHE and EPA are currently continuing to pursue constructing the repository at the Druid site. However, this comment is duly noted, and options for other sites such as the Gem/Franklin site are also being considered.

COMMENT: The Clear Creek Watershed Foundation noted their support for additional non-point source work beyond that called for by the OU4 Feasibility Study and Proposed plan.

RESPONSE: Superfund efforts including those called for by the OU 4 Record of Decision are intended to address only the most significant impacts of historic mine wastes with the objective of attaining the stated remedial action objectives. These objectives include water quality improvements along the North Fork and main stem of Clear Creek, and the protection of human health and the environment. The watershed is a complex basin with many mine waste sources including both discrete point sources and numerous non-discrete non-point sources that are not proposed to be addressed by the Superfund efforts. Efforts to address additional nonpoint sources within the basin will be important to the ongoing cooperative efforts within the watershed to foster continuing sustainable improvements to water quality and to the revitalization of impacted lands.

COMMENT: The Colorado Division of Wildlife (CDOW) raised concern about using the Argo Tunnel water treatment plant to treat mine waters from the North Fork of Clear Creek basin because of concerns about possible negative impacts to the main stem of Clear Creek. CDOW supports the preferred alternative, Alternative 4B, and then would support alternative 3B, which would involve a new treatment facility within the North Fork of Clear Creek basin as its second choice. CDOW has concerns with Alternatives 3 A and 3C because they propose using the Argo Tunnel treatment plant to treat mine waters from the North Fork of Clear Creek basin.

RESPONSE: CDPHE and EPA believe the remedial alternatives that involve using the Argo Treatment plant to treat the mine water from the North Fork of Clear Creek could be implemented without negative impacts to Clear Creek. Prior to implementing Alternatives 3 A or 3C there would need to be confirmation of the interconnection of mine workings and the ability to transport the water from the North Fork basin via the Argo Tunnel. The Argo treatment facility would need to be evaluated regarding its ability to handle the additional flow of water from the Gregory Incline, the National Tunnel and Quartz Hill. The Feasibility Study estimated upgrades of approximately 3 million dollars would be implemented at the Argo facility to address the routine additional flow. The most difficult potential impact to assess and address would be whether using the Argo Tunnel as a conveyance would unacceptably increase the risk of a tunnel surge which would require by-pass of the treatment facility and would adversely impact Clear Creek. The Argo facility currently has limited surge protection. Surge protection could be addressed by partial tunnel rehabilitation and installation of a surge control flow-through tunnel plug. Separate from the upgrade costs for handling the routine increased flow noted above, the estimated capital cost of tunnel rehabilitation and a flow-through plug is also 3 million dollars. Tunnel rehabilitation and flow-through runnel plugging were not included in cost estimates for Alternates 3A and 3C. Based on the information evaluated to date, CDPHE and EPA consider Alternatives 3A and 3C to be viable, technically feasible, and implementable alternatives. However alternative 4B was determined to provide better balance of the nine criteria and was thus selected in the Record of Decision.

COMMENT: The Upper Clear Creek Watershed Association suggested incorporating the remedial action objective of brown trout survival for segment 13b explicitly in the remedial action objective rather than in the comments following the statement of the remedial action objective.

RESPONSE: The remedial action objective for segment 13b has been modified to explicitly include the objective of survival of brown trout for segment 13b (North Fork of Clear Creek).

COMMENT: The Upper Clear Creek Watershed Association raised the concern over whether the remediation goals for zinc and copper are sufficiently protective considering Division of Wildlife recommendations for instances where elevated concentrations of both zinc and copper are present. The comment requests that after remediation is implemented, the appropriateness of the zinc remediation goals be reevaluated based on whether the goal for brown trout reproduction and/or survival are met. If in the future the remediation goals are not met, Upper Clear Creek Watershed suggests additional remediation should be performed to meet the brown trout goals. They would ultimately like to see a reproducing brown trout population in North Fork.

RESPONSE: For both the main stem of Clear Creek and for the North Fork of Clear Creek, achievement of the remedial action objectives is more important than achieving the numeric remediation goals because remediation goals are set to facilitate achieving the remedial action objectives. Therefore, the success and protectiveness of the remedy would be based first and foremost on whether the remedy results in a surviving brown trout population on the segment 13b of the North Fork of Clear Creek and a viable reproducing brown trout on segment 11 of the main stem of Clear Creek. We agree there is some uncertainty as to the synergistic effects of zinc and copper. Therefore the Agencies agree with the Upper Clear Creek Watershed Association's suggestion that the remediation goals be reevaluated based on whether the remedial action objectives of brown trout reproduction and/or survival are attained by the remedial action. Following the implementation of remedial action, the effectiveness will be assessed based on whether the remedial action objectives and remediation goals are attained. If they are not attained, consideration of either additional remedial action and/or some modification of the remediation goals may be warranted. In the future, one purpose of the five-year review process, required by CERCLA, will be to assure such evaluations are performed and to facilitate the Agencies review of whether the remedial action achieves its objectives and is protective of human health and the environment. The remediation goals that were selected are acknowledged to be based on a balance between concentrations that are projected to be reasonably achievable given the proposed remedial alternatives and considering various hardness-based toxicity recommendations of the Division of Wildlife. The Division of Wildlife recommendations are based on Clear Creek-specific information, research and data from other streams, and laboratory studies. It should be noted that North Fork of Clear Creek has very high hardness compared to most streams, making correlations to other steams and to the main stem of Clear Creek difficult.

COMMENT: The Upper Clear Creek Watershed Association (UCCWA) supports the Feasibility Study and Proposed Plan approach of using a seasonal approach to set remediation goals. The commenter points out that the Water Quality Control Division (WQCD) has calculated Table Value Standards for Clear Creek using an average hardness, not a seasonal hardness as was done by the Feasibility Study and Proposed Plan. The comment notes that the preliminary remediation goals for low flow would therefore not be as stringent as WQCD water quality standards calculated based on nonseasonal average hardness, and suggests the Record of Decision should identify this as an issue to be addressed during the next triennial review by the WQCD. Additionally UCCWA hopes that the CDPHE Hazardous Materials and Waste

Management Division and EPA will support a seasonal approach to water quality standards for these segments (11 and 13b).

RESPONSE: The Feasibility Study and Record of Decision's use of the seasonal standards is indication of the Hazardous Materials and Waste Management Division's and EPA Superfund Program's belief that use of seasonal standards for the metals of concern to the Superfund work is appropriate. Within CDPHE, Hazardous Materials and Waste Management Division (HMWMD) is delegated the implementing authority for complying with water quality standards for CERCLA remedial actions. The associated interpretations are done in consultation with the WQCD but do not need to be affirmed by the Water Quality Control Commission (WQCC) as is the case for permit and modifications to stream standards for permitted entities. In the Record of Decision and through the Applicable and Relevant and Appropriate Requirements (ARARs), HMWMD determined that for the proposed CERCLA actions and the specific metals of concern, use of a seasonal approach is compliant with the applicable water quality standards. While other regulated parties may not have the ability to make such interpretations, they will have the opportunity, either site specifically or, during the next triennial review, to request to use a similar approach. We believe it would be inappropriate for HMWMD to suggest to WQCD and WQCC the means of implementing water quality standards on other than CERCLA matters. Use of seasonal standards was reviewed by WQCD and concurred with as appropriate for the proposed CERCLA actions.

COMMENT: Gilpin County comments supported aggressive sediment controls, and the Upper Clear Creek Watershed Association supported Tier 2 sediment controls, which include both tributary and North Fork of Clear Creek sediment controls.

RESPONSE: Modeling and predictions of the effectiveness of the various alternatives indicated that the alternatives that included sediment control on both the tributaries and on North Fork of Clear Creek (4B and 3C) would offer the greatest likelihood of achieving the remediation goals and remedial action objectives. Alternatives that included the less aggressive Tier 1 sediment controls would potentially have difficulty meeting low flow zinc remediation goals, which are critical to attaining the remedial action objectives. This is one of the main reasons alternatives 4B and 3C achieved the highest ranking for overall protection of human health and the environment and compliance with ARARs (which are threshold criteria), and was an important consideration in proposing and selecting Alternative 4B as the selected remedy.

COMMENT: The Upper Clear Creek Watershed Association and the Clear Creek Watershed Foundation support the completion of the repository.

RESPONSE: Although not specifically included as a remedial measure called for by the OU4 Record of Decision, the Agencies continue to pursue implementation of an on-site mine waste repository. Efforts to implement the repository are being made as a part of the remaining and ongoing OU3 work. If the Agencies are successful in implementing a repository, it will increase the efficiencies of cleanup for OU4 as well as OU3.

COMMENT: The Upper Clear Creek Watershed Association and a private individual commenter caveat their support of the selected alternative. They note concern about the limited capacity of the Bates Hunter treatment facility, both ongoing and also during initial mine dewatering. In addition, concern over the future effectiveness of passive treatment was noted.

RESPONSE: The Upper Clear Creek Watershed Association raises a good point that the Bates Hunter facility will not have much excess capacity. Modeling of the anticipated effectiveness of the selected alternative is based on treating 100% of Gregory Incline flow, 100 % of the National Tunnel and the base flow of Gregory Gulch ground water during low flow conditions (September through April). Load reductions for these sources were assumed to be 99% for Gregory Incline (active treatment), 85% for National Tunnel (lower because of the passive system) and 25% for Gregory Gulch (treatment would be effective but limited by the ability to collect non-point sources). In the high flow setting, the loading reduction for the Gregory Incline was assumed to be only 85%, instead of 99%, to model and account for the potential that the Bates Hunter treatment plant capacity is limited and flow capacity may be exceeded some during high flow conditions. With the exception of copper, all North Fork remediation goals are anticipated to be achieved during high flow. Ideally, a higher flow capacity for water treatment system would be available. However, estimates for the cost of constructing a new treatment facility in the North Fork basin were much higher than for the public/private cooperative treatment using the Bates Hunter treatment facility. Based on overall evaluation of the nine criteria it was determined that Alternative 4B, which uses the Bates Hunter, would provide a better balance of the nine criteria than the alternative that includes constructing a larger capacity new facility. During initial mine dewatering, treatment capacity may indeed be more limited than of other times. For this reason, the Agencies will consider performing initial dewatering of the Bates Hunter mine during low flow, when other water sources are minimized. Other options such as temporary treatment at lower pH in order to increase the ability to handle greater water flow could be considered. The details of the relationship between the Bates Hunter mine dewatering and treatment of the Gregory Incline and Gregory Gulch waters has not been resolved. The comments raised by the Upper Clear Creek Watershed Association raise valid concerns that will be considered as such plans are made.

With respect to passive treatment, CDPHE and EPA believe that an effective passive treatment system can be constructed and operated. After implementation of the remedy and following the initiation of operations, the Agencies will have a much better sense of the vulnerabilities of the system and of the flow and capacity limitations. Success will ultimately be determined primarily by whether the remedial action objectives are attained. Initially, the effectiveness of the selected alternative would be assessed, and later the five-year review process is intended to identify whether the remedy remains protective. If it is determined that a remedy is not effective, it may lead to additional remedial action or may lead to reconsideration of the remedial action decisions made in the Record of Decision.

COMMENT: The Upper Clear Creek Watershed Association and an individual commenter specifically support the water treatment of Gregory Incline, Quartz Hill Tunnel and the National Tunnel, as well as supporting a water treatment solution that discharges treated water to the North Fork.

RESPONSE: The Feasibility Study shows that water treatment of the main point sources is an essential component for any alternative to achieve remedial action objectives and remediation goals. Without treatment, the sediment efforts alone provide only limited improvements. Treating and discharging to the North Fork basin will maintain the flow of the mine tunnels in the North Fork of Clear Creek. The mine tunnels contribute as much as 15% of the flow of the North Fork of Clear Creek during low flow. This water will dilute remaining in-stream metals concentrations, and will help maintain a larger minimum base flow than would be the case if the tunnels are treated at the Argo Tunnel plant. The selected alternative also provides additional hardness to the North Fork of Clear Creek that will temper the toxicity of metals slightly. For these reasons, alternatives that treat water and discharge it to the North Fork of Clear Creek basin rather than conveying the water to the Argo Tunnel are more protective of the North Fork of Clear Creek than remedies that utilize the Argo treatment facility for treatment.

COMMENT: The Upper Clear Creek Watershed Association supports additional work in Virginia Canyon and on the main stem of Clear Creek

RESPONSE: While beyond the scope of the areas addressed by OU4, the agencies acknowledge the Association's concerns. Ongoing actions that will foster additional improvements along the main stem, including the Superfund work to contain and treat Virginia Canyon ground and surface waters, are important to achieve remedial action objectives and remediation goals on the lower reaches of the main stem of Clear Creek. The OU4 Feasibility Study shows that simply addressing the North Fork alone will not be sufficient to achieve remedial action objectives on the main stem of Clear Creek. Following implementation of the Virginia Canyon ground and surface water remedy, the Agencies will be able to assess the effectiveness of these actions to protect the main stem of Clear Creek, and to assess the extent of additional Virginia Canyon or other cleanup that may be warranted.

COMMENT: Comment was received from a private individual regarding potential ownership and knowledge of certain mine workings.

RESPONSE: This comment is noted and will be considered as remedial efforts proceed.

COMMENT: The Colorado Historical Society noted Section 106 consultations and reviews will be required and noted that the Central City/Black Hawk National Historic Landmark District and the Argo Tunnel are within the project area.

RESPONSE: The Agencies agree that coordination with the Colorado Historic Society will be required to assure compliance with applicable requirements. The Agencies plan to consult and coordinate with the Colorado Historical Society as remedial actions are implemented.

Appendix D

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